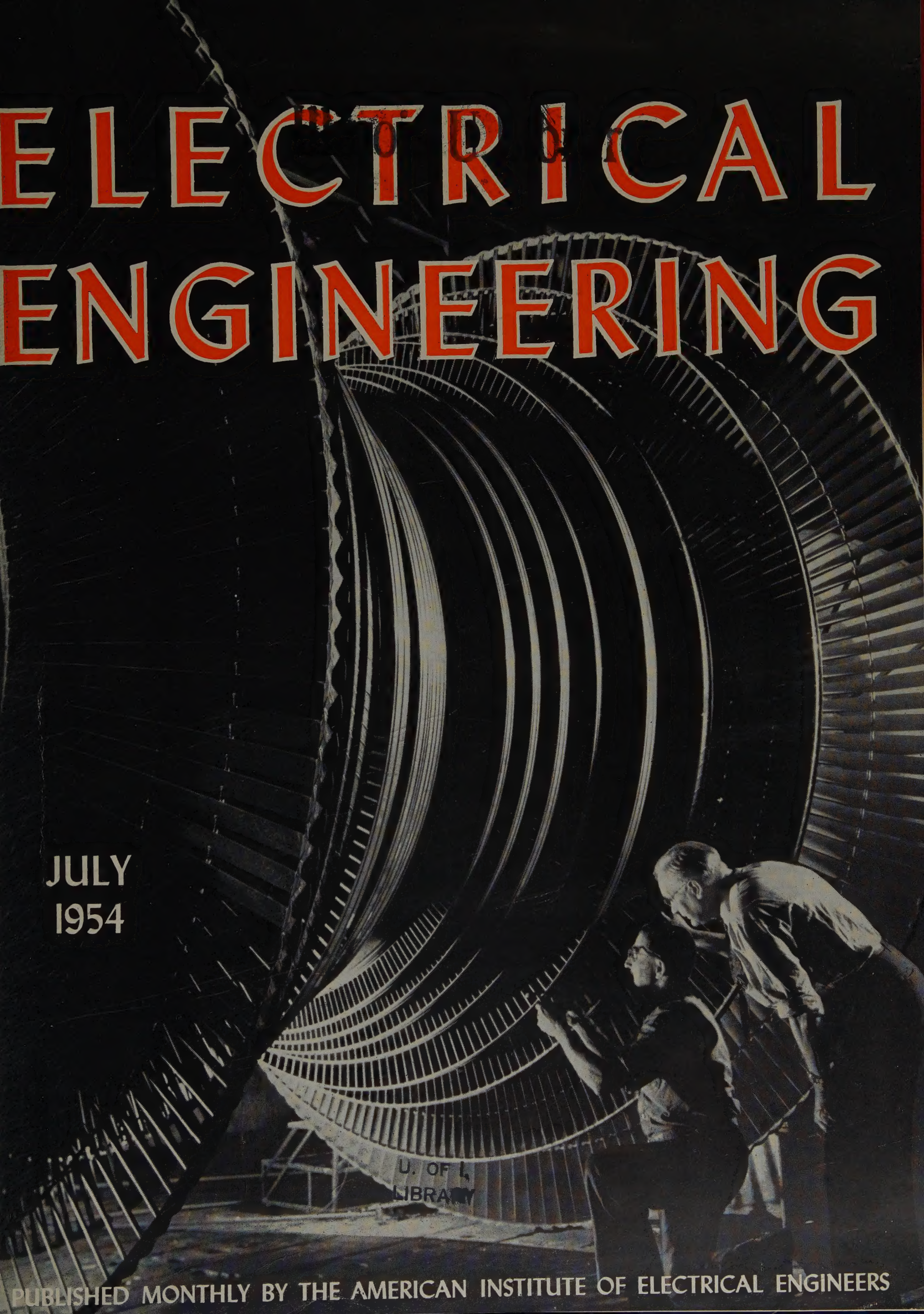
ELECTRICAL ENGINEERING



JULY 1954

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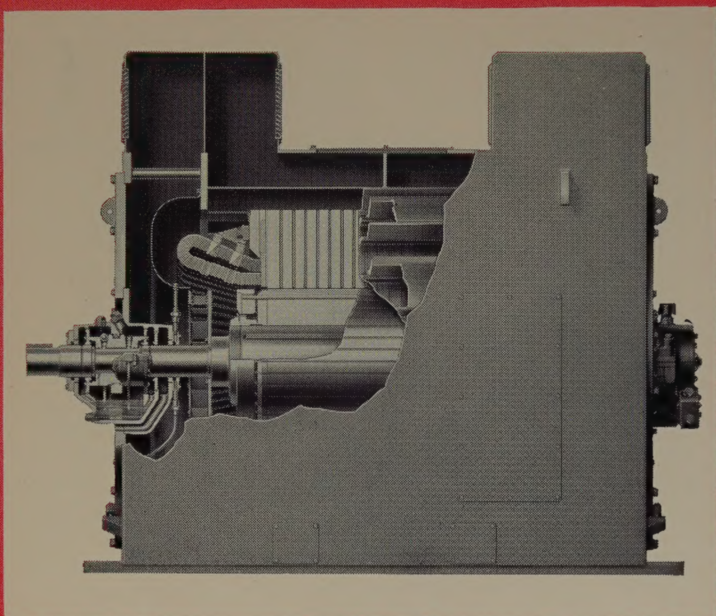

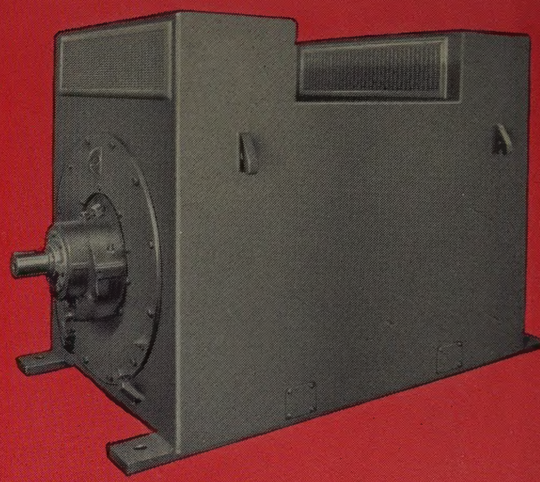

ALLIS-CHALMERS
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MOTORS

New features improve 2-pole motors long known for reliability and low maintenance.

New ventilating arrangement features top air intake and discharge *plus* spiral stator core ventilation. Top intakes (available with filters) keep motor clean and make motor room cleaning easy; top discharge adds to personnel comfort. Spiral ventilation — used in turbine generators — assures even internal cooling . . . combines with centrifugal fans and baffled air passages to reduce noise.

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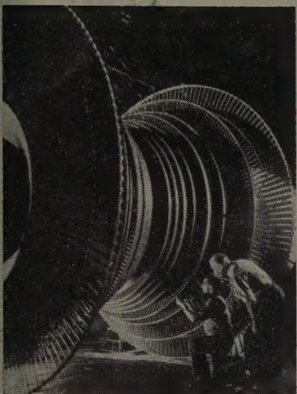

The Cover: Low-pressure spindle made by Allis-Chalmers Manufacturing Company for 120,000-kw cross-compound reheat steam turbine of the Wisconsin Electric Power Company. Longest blade of 178,500-pound spindle is 40 inches, maximum tip diameter, 13 feet 4 inches. Tip speed of this blade when operating will be 1,260 feet per second with centrifugal pull of 81,000 pounds.

JULY
1954

New Horizons for Engineers . . . H. F. Smiddy . . . 587
Impact of the Atomic Energy Program on the Electrical Industry . . . G. W. Thaxton . . . 592
The Decilog: A Unit for Logarithmic Measurement . . . E. I. Green . . . 597
Ten Founding Fathers of the Electrical Science—IV . . . Bern Dibner . . . 600
Fundamentals of Flashing of Diesel-Electric Motors and Generators . C. A. Atwell . . . 603
Application of Shunt Capacitors to Network Systems . . . Hamilton Brooks . . . 609
A New Continuous-Feed Facsimile Scanner . . . John V. L. Hogan, G. M. Stamps . . . 615
Vector Theory of Synchronous Machines . . . S. L. Mikhail . . . 622
The Threshold of Perception Currents . . . C. F. Dalziel . . . 625
Let's Reduce the Cost of Lighting . . . E. A. Linsday . . . 632
Test Results of an Inner-Cooled Generator . . . W. C. Brenner, P. R. Heller . . . 638
Automatic Inventory System for Air Travel Reservations . . . M. L. Haselton, E. L. Schmidt . . . 641
A Transmission-Loss Penalty Factor Computer . . . C. A. Imburgia, L. K. Kirchmayer, G. W. Stagg . . . 649
An Application of Operations Research in the Power Field . . . E. W. Boehne . . . 655

TECHNICAL PAPER DIGESTS

Submarine Cable for 100-Kv D-C Power Transmission . . . B. O. N. Hansson . . . 602
A New 115-Kv Stored-Energy-Type Capacitor Switch . . . D. C. Prince, Paul Wildi, W. H. Clagett, J. A. Gregg . . . 614
Transient Performance of Servomechanisms . . . R. C. Lathrop, Dunstan Graham . . . 620
Applying Short-Time Memory Units to Compensators . . . D. J. Ford, J. F. Calvert . . . 621
Eddy-Current Phenomena in Ferromagnetic Materials . . . H. M. McConnell . . . 624
Co-ordination of Fuel Cost and Transmission Loss . . . W. R. Brownlee . . . 631
Impulse Ionization and Breakdown . . . G. M. L. Sommerman, C. J. Bute, E. L. C. Larson . . . 636
Mechanism of Impulse Corona and Breakdown in Oil . . . T. W. Liao, J. G. Anderson . . . 637
New 12-Channel Open-Wire Carrier System . . . A. G. Ewing, F. W. Frazee, Dale Welling . . . 640
Sampled-Data Control System Transient Analysis . . . G. W. Johnson, D. P. Lindorff . . . 647
An Improved Transformer Differential Relay . . . C. A. Mathews . . . 648
Switching Surge Voltages in High-Voltage Stations . . . I. B. Johnson, A. J. Schultz . . . 653
The Equivalent Circuit of the Schräge Motor . . . C. L. Sheng . . . 654
Calculating Amplitudes in Transient Responses . . . D. G. Lewis . . . 659
Properties of Optimum Power Transformer Design . . . H. L. Garbarino . . . 660

MISCELLANEOUS SHORT ITEMS: Microfilming Machine, 599; European Television Hookup, 608; Phototube for Inspection Uses, 613; NEMA Adds House Heating Section, 619; Commercial Reactor Equipment, 623; Air-to-Air Guided Missile Can Be Fired by Jet Planes, 630; Largest Circuit Breaker Shipped, 635; Chemical Milling Process for Aircraft and Guided Missile Parts, 652

Institute Activities . . . 661
AIEE Personalities, 674; Obituaries, 680; Membership, 680
Of Current Interest . . . 681
Letters to the Editor, 687; New Books, 687; Pamphlets, 688
Industrial Notes . . . 18A
New Products, 30A; Trade Literature, 48A
Index to Advertisers . . . 72A

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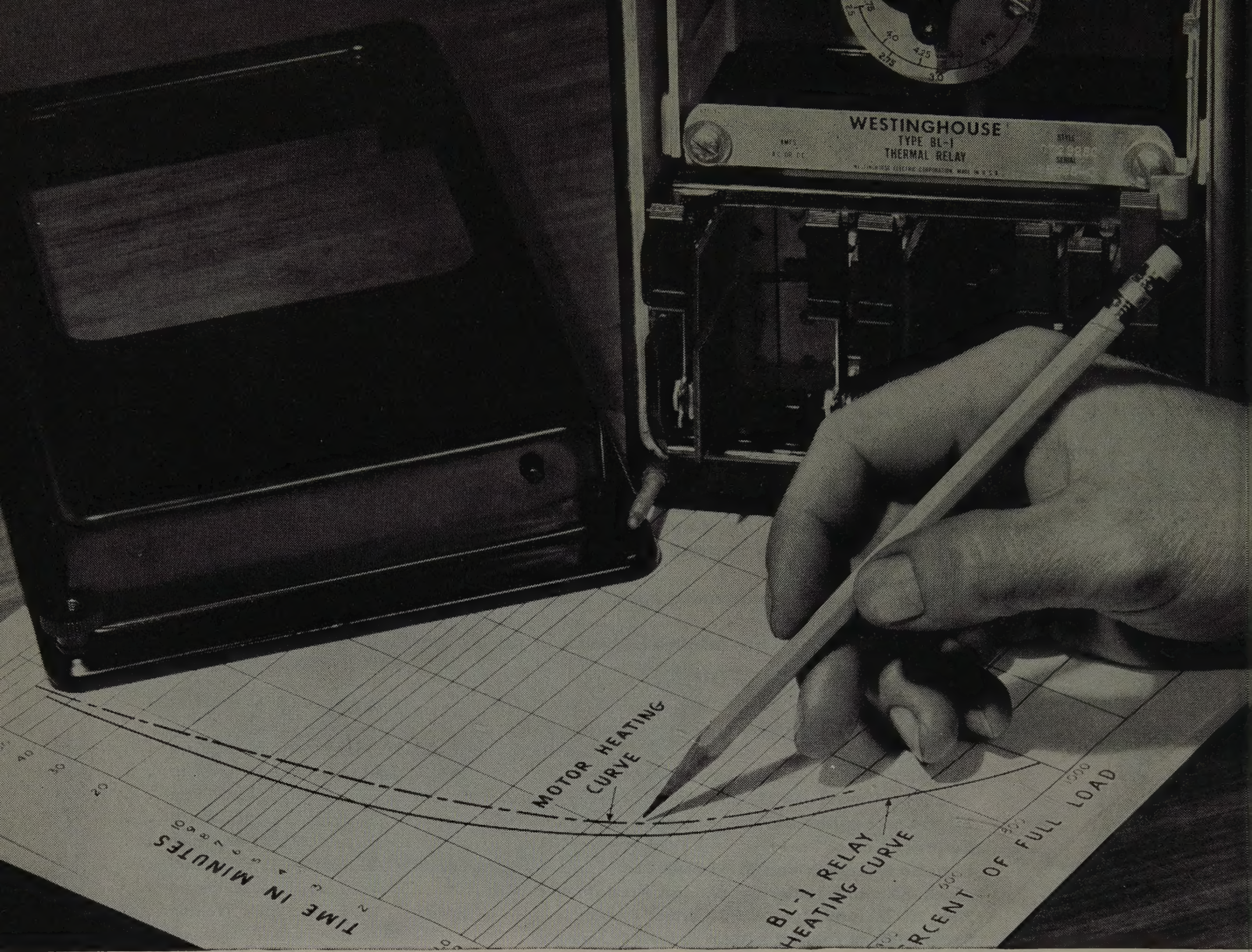

New Westinghouse thermal overload relay matches your motor heating curves

The new Westinghouse BL-1 relay for protecting motors and other electrical apparatus from overheating gives a much closer match than previous relays to average heating curves, and over a wider operating range. Matching heating curves is important since the BL-1 is a "replica" relay that is heated internally by a current proportional to the current in the protected machine. Because it accurately duplicates heating conditions within the apparatus, it lets you take advantage of the intermittent overload capacity of a machine. It often permits the use of a smaller size apparatus for a given application at substantial savings.

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HIGHLIGHTS . . . .

Ten Founding Fathers of the Electrical Science—IV. Alessandro Volta was responsible for the forward move which made electricity an important tool in the service of man. His experiments in contact electricity which led to the discovery of the voltaic cell and provided a practical source of continuous electric current are described (*pages 600–01*).

New Horizons for Engineers. In today's industrial society there is greater challenge and opportunity for the engineer than ever before. There are two fields in which he can put his talents to work; in the creative engineering work, or in the management field (*pages 587–92*).

Operations Research in the Power Field. The analytical technique of operations research has proved a new tool of great value in many fields. This is a report of its application to a study of hydro-thermal electric systems (*pages 655–8*).

Application of Shunt Capacitors to Network Systems. The requirements of secondary network capacitors are discussed and the equipment recently made available is described. The emphasis is on practical operation, but one requirement is the availability of suitable ratings of equipment. Thus certain factors involved in the economics and choice of ratings also receive consideration in this article (*pages 609–13*).

Impact of the Atomic Energy Program on the Electrical Industry. Greater demands for greater amounts of electric power have been made upon American suppliers. What these demands are and how they are being met is discussed (*pages 592–6*).

News Index

Institute Activities....................661

North Eastern District Meeting................661
Future AIEE Meetings........................661
Cornell Wins Branch Paper Prizes............663
Northern Textile Conference..................664
Symposium on Electronic Components.........664
Committee Activities.........................672
AIEE Personalities...........................674
Obituaries...................................680
Membership...................................680

Of Current Interest..................681

First American 230-Kv Pipe-Type Cable.......681
Future Meetings of Other Societies...........681
Parachute Telemetering Facilitates Testing.....682
Ceilometer Records Cloud Ceiling Changes....683
Letters to the Editor.........................687
New Books....................................687
Pamphlets....................................688

The Decilog: A Unit for Logarithmic Measurement. A brief history of the decibel is followed by a discussion of the present difficulties and the various suggestions made to improve the situation. The decilog is proposed as a supplement to the decibel to be applied to any ratio whatever in an invariant manner (*pages 597–9*).

A New Continuous-Feed Facsimile Scanner. The work being done in the facsimile field is reviewed and one type of facsimile scanner which is more versatile than the typical lathe-type scanner is discussed in some detail. Small, light, and flexible in terms of the type of optical system, it can handle inflexible copy, and has no ambient light problem. It is felt that this scanner should broaden the field for application of the electric transmission and reproduction of graphic material (*pages 615–19*).

Fundamentals of Flashing of Diesel-Electric Motors and Generators. Flashing may occur with no appreciable damage to a motor or generator or it can be so serious that the locomotive cannot remain in service. An examination of some of the factors which cause flashing and so should assist in reducing the number of flashes, is considered in an article in this issue (*pages 603–08*).

Vector Theory of Synchronous Machines. The transformation from phase to direct, quadrature, and zero components is a valuable tool in the analysis of the synchronous machine. This transformation as used by Margand and established as a theory by Park is discussed and a simplified vectorial approach leading to Park's equations is carried out (*pages 622–3*).

Automatic Inventory System for Air Travel Reservations. A running inventory count of available passenger accomodations on all scheduled flights of a major air line out of the New York City area for 10 days in advance is kept automatically. It makes use of a rotating drum with a magnetic coating for the purpose of data storage (*pages 641–6*).

A Transmission-Loss Penalty Factor Computer. This computer can calculate, in a minimum of time, the transmission-loss penalty factor to be used to adjust the relative position of the incremental fuel strips of the slide rule to include the effects of the transmission losses. The co-ordinated operation of the slide rule and this computer will furnish a flexible and accurate method whereby all the various and rapidly changing conditions both within the plant and on the transmission system may be taken into account to improve system economy (*pages 649–52*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

The Threshold of Perception Currents. An analysis of results of many experiments made to determine the smallest currents just perceptible when holding or touching different appliances, hand tools, or small wires permits establishing perception levels for large groups of normal men and women. The results of further experiments are given (*pages 625–30*).

Let's Reduce the Cost of Lighting. The subject of lighting is all important in any plant and there are ways and means in which money can be saved. How replacements and maintenance affect the factors involved are discussed (*pages 632–5*).

Inner-Cooled Generator Test Results. A series of electrical and mechanical tests were conducted at various pressures up to 96 psig, and those made at 30 and 45 psig are reported here (*pages 638–9*)

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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New Horizons for Engineers

H. F. SMIDDY
MEMBER AIEE

Now, as never before, the opportunity for professional success awaits every engineer who has the imagination and initiative to take advantage of it. In today's complex industrial society there is a dual demand for his talents, either as a creative, individual engineer, or as a manager of engineering work and the business enterprise as a whole.

THE TITLE of this article is at once both optimistic and challenging, and intentionally so.

To begin with, there is no insurmountable reason why any competent engineer should not increase his personal income very greatly in the next 5 years. Whether he will do so or not is essentially up to him personally; and will be a function of his willingness to think boldly and soundly rather than merely to wish and wait.

The point is that such a result is there to achieve, for basic and fundamental reasons which will be outlined, if he has the imagination and the courage to reach out for it through persistent and thoughtful application of the skills professional electrical engineers have at their command.

THE CHALLENGE

TO BRING out the logic of this challenge, this article will show that the following seven points are factually accurate, and in turn thus will demonstrate that the opportunity both to multiply his income and to broaden greatly his service to our complex industrial society is begging for the taking before each technically trained engineer of this age.

1. Advancing science and technology comprise one of the major factors fixing the nature of society and the problems of organizing and managing its constituent institutions today.
2. The impact of such scientific and engineering developments, and of the power over materials and equipment which they bring, requires corresponding creative thought and effort to keep social progress and human relations abreast of technical progress.
3. The necessity to organize and to manage the business and other basic institutions of an increasingly mechanized civilization competently, calls peculiarly for the kind of skills that engineers—and specifically electrical engineers—possess.
4. The electrical engineer who is awake to these potentials has his choice of two equally challenging fields of service to participate in their realization; either by better individual creative performance in the field of electrical engineering as such, or by direct participation in the sphere of management in which results are achieved by leadership in planning, organizing, integrating, and measuring the activities and performance of fellow workers, rather than by personal productive output as such.
5. The needs, challenges, and rewards for contributions for better technical electrical engineering effort are especially clear at this time.
6. Similarly, the electrical engineer, who desires to do so, has special qualifications and opportunities to transfer from technical to managerial work under these conditions.
7. The only "missing ingredient" to retard climbing either of these paths to greater performance, service, recognition, and income is the will of the individual engineer himself. Therefore, any competent electrical engineer can increase his income very greatly in the next 5 years if he personally will move sincerely and intelligently to do so.

Consider for a moment each of these seven points and explore both their validity and the logic of the conclusion which flows from their cumulative potential.

Point 1. It is hardly essential to labor the idea that science and technology represent dominant forces bounding and shaping today's industrial society, but the following three items will make the record clear in this respect.

The first was an experience which occurred when the author was trying to write a paper for the 10th International Congress of CIOS, the International Committee for Scientific Management, in Sao Paulo, Brazil.

The sixth of eight technical sessions there, in a program built around the broad theme of "The Leadership Role of Management," dealt with the subject, "Policy Making as Affected by Conditions Outside the Control of Management; Particularly Those Related to Credit (Finance) and Taxation," under the leadership of the French national management organization.

The French, in outlining this topic, suggested that credit and taxation might be the dominant external influences. After surveying some 83 American leaders in business, education, and government in preparing the United States collaborating material for this topic, however, it early became apparent that credit and taxation, important as they are, represent only symptoms of deeper causative factors that really require fundamental understanding in policy making today.

Such research showed, instead, that the four true primary factors were (1) multiplying technology, (2) competition, (3) big government, and (4) individual and collective public opinion.

It is striking to note that "multiplying technology"

Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, and recommended for publication by the AIEE Committee on Management.

H. F. Smiddy is with the Management Consultation Services Division, General Electric Company, New York, N. Y.

headed this list. Further confirmation might be found in Fenton Turck's article published in the *Scientific Monthly* in 1952.[1]

The second item is the powerful Calvin Rice Memorial lecture which Colonel Lyndall Urwick delivered at the Chicago Centennial of Engineering in September 1952.[2] As Colonel Urwick said so well:

"In little more than 250 years, the scientific curiosity released by the Renaissance has resulted in a major cultural revolution. Man has acquired a control over his material environment quite unprecedented in the history of the human race....

"Why then with this tremendous power in our hands, with so much that is hopeful just over the horizon, should we be rent with factions, afraid, as many are afraid, of the very future of humanity as a species?

"For a very simple reason. This new-fangled power over material things, these gifts which engineering above every other profession has placed within our reach, are not unconditional. The price of power is understanding, the insight to use it right. As every engineer knows, a culture dependent on power-driven machinery has its own postulates. Above all, the proper, the effective use of modern machinery demands of men an intricacy of co-operation, a refinement of social discipline, such as they have never before contemplated. All around us is the evidence of this truth."

Finally, the third item relating to point 1 of the seven points, is the pamphlet "Cybernetics and Society," summarizing the proceedings of a historic meeting of the New York chapter of the Society for the Advancement of Management on that subject on November 16, 1950, which should be particularly of interest to electrical engineers.

It is a compilation of profound remarks that evening by Norbert Wiener, Luther Gulick, Alex Rathe, Carl Heyel, Al Seares, and Victor Dorkovich, who posed frankly the import, for both engineers and for managers, of the "Second Industrial Revolution" which is so obviously upon us; and which makes such powerful demands for a quality of technical and managerial statesmanship of previously unparalleled significance.

As Wiener himself then summarized, "As to the things that I see in the immediate future . . . the machine, its repercussion on society, the human attitudes that we must take, the fact that we must not worship the machine . . . please notice, that the theory of communication and of organization is principally one applying to the living organism, as well as to the machine."

Wiener further significantly noted that one ultimate result of the degree of automation of both manual and mental work that is already in being is to indicate the potential displacement of workers "that we never do employ again"; and that in handling the social-political responsibilities so imposed, there is a transcending problem for economic and for political and social statesman alike to recognize that, in the face of changes so radical, "the statesmanship of management cannot stop at the edge of the individual firm."

It is indisputable, therefore, that advancing science and technology—which engineers understand and direct—do go far to fix the nature of society and the problems of organizing and managing its constituent institutions today.

Point 2. This point indicates that the impact of such scientific and engineering developments, and of the power over materials and equipment which they bring, requires corresponding creative thought and effort to keep social progress and human relations abreast of technical progress.

The remarks of Colonel Urwick and of Dr. Wiener are as pertinent here as with respect to point 1. If further evidence seems requisite, even casual perusal of the program topics for practically any management or industrial association conference these days will more than provide it. Growing awareness of this terrible need is indeed one hopeful sign that the chance to meet it, and in time, is still ours.

Point 3. "The necessity to organize and to manage the business and other basic institutions of an increasingly mechanized civilization competently, calls peculiarly for the kinds of skills which members of the engineering profession possess."

Fundamentally, this is correct because both technical knowledge and a professional attitude in its application are root requirements in the premises; and the good engineer has both.

The important connotation, though, is that such knowledge and such attitude are as important for the manager as for the engineer in developing and operating these complex enterprises in the paradoxical niche which they now occupy in our economy and society; paradoxical because society recognizes its deep need for their services for its progress on the one hand, but demands uncompromisingly, on the other hand, that their contributions be fairly in the public interest at all times, as the price of giving them the challenge and the chance to render their services on a basis profitable enough to allow and encourage needed efficiency and expansion.

More, of course, than his colleagues in any other functional field of work, the engineer, as either individual, creative designer, or as manager, not only understands but actually creates the technical background for such operations and progress. Every engineer naturally takes this for granted.

Many engineers, however, pass over too lightly the significance of the professional characteristics of engineering education and of technical experience and qualifications. The gist of it is that in these modern industrial businesses in which engineers work, or for which they, as educators, prepare young men, or which they analyze and even regulate as government officials, the work of management itself now has become "professional" in nature to an ever-increasing degree.

Hence, electrical engineers, with a "built-in" understanding of the obligations involved in bringing a truly professional attitude and approach to the day's work, have a distinct edge if they elect a managerial rather than a technical path. This is because they both understand technology and also appreciate the service spirit and calls

of the professional requirements with which all managers must struggle today.

Point 4. This point only draws the obvious conclusion from this prevailing state of affairs, namely, that an electrical engineer, awake to such potentials, has a double chance for personal progress and success.

He can travel either the path of better personal, creative technical performance, or that of personal advancement as a manager who guides the successful and profitable use of both the human and material resources of a business, or other useful institution, towards its planned objectives.

Point 5. This deals directly with the engineer's opportunities if he decides, as an individual, to travel the first-named path; that is, to strive as a personal, creative technical engineer.

Speaking to an AIEE meeting in 1951, Vice-President A. C. Monteith said:[3]

"A past issue of *Life* discussed the 'accelerating rate of scientific progress.' The startling statement was made that more progress was made in the first 50 years of the 20th century than in the previous 5,000 years. The article showed the increase in the use of power, the increase in the use of communications, and also the improvement in the destructive power that man has evolved out of the long step from the use of black powder shells in 1900 to the atomic bomb in 1945....

"What has made all this possible? Engineering. Look at the marvels of America today; analyze them and you will find that engineering is the basis of practically all of it. Engineering has even taken over production on the farm. The tractor, hay drier, separator, milking machine—all are engineered devices, many driven by electric power.

"The new automobile, television wonders, buildings, roads—all are engineering accomplishments. What will develop out of atomic energy will be dependent on what engineers can do with it.

"Look at the last war with its airplanes, tanks, radar, superguns, bombs. All were engineering achievements, and war in the future would be even more a matching of engineering skill....

"Our greatest problem today is to make the public understand the need for superior engineering and for engineers...."

The deep nature of such technological impact on business becomes further apparent when it is realized that science, in addition to producing a mechanical revolution, also has produced essentially a biological revolution which, for example, is estimated to add some 50 to 75 million more people to the population of the United States alone in the next 50 years. The whole economy must be expanded proportionately to meet both the civilian and military requirements of such a population.

The problem was presented this way in the *Industrial Bulletin* of Arthur D. Little Inc., consulting chemists and engineers, for November 1952:

"The task set for technology in its struggle to extend the 'Resources for Freedom' will be coupled with other tasks of equal scope: to find the necessary manpower, to learn to adapt scientific advances more rapidly to meet public need, and to raise the required capital."

Thus, to summarize point 5, there are not enough engineers on the one hand; and there is overwhelming need for better performance as to all aspects of professional, technical engineering on the other hand.

Clearly, if the engineer does not see the chance to increase his income very greatly under such conditions, directly in the technical field of electrical engineering itself, he hardly can claim that it is lack of opportunity which holds him back.

Point 6. The electrical engineer, who desires to do so, also has special qualifications and opportunities to transfer from technical to managerial work in today's expanding economy.

As already emphasized, whether to move over from technical to managerial work is a personal choice. There are outstanding chances for talent in either. This has been proved in point 5 for those who elect the path of personal engineering effort. The point here is that equally wide and remunerative openings prevail for those who elect the path of progress through management work as such.

Briefly, one may define "managing"—as a distinct and as a professional type of work itself—as "leadership through planning, organizing, integrating, and measuring the use of available human and material resources of an enterprise to achieve chosen optimum objectives well, economically, profitably, and on time."

The separate and professional work of managing under this concept involves exercise of responsibility, with commensurate authority, to make decisions, to take action, or to recommend decisions or action to others, as the means of achieving optimum results.

Both because of the engineer's "built-in" professional attitude and because of his trained understanding of technology and its implications, electrical engineers who are so inclined should have a highly preferred status in competing for the expanding and ever-more-complex jobs for which competent managerial talent is being sought on all sides.

The shortage of able managers is, if anything, even more acute than the shortage of engineers, and is getting worse.

That, of course, is the underlying stimulant of the gargantuan spate of both real and ersatz "Manager Development Programs" which are receiving such spectacular publicity in all kinds of management and industrial enterprises, circles, and associations at this time. They do indeed represent something of a transient phenomenon of our day, which would justify an article in themselves. Suffice it to say, that irrespective of the validity, or lack of it, of any particular such scheme, their very existence cumulatively proves beyond dispute the reality of the manager shortage which they aim to relieve.

In the first place, of course, there is a definite shortage of managers of direct engineering departments and components. In an article on "Management of Engineering

Work," T. M. Linville develops both the need for better managers of engineering work and components and also the ways that the individual can move in to meet that need.[4]

It should be emphasized in addition that the need for general managers is equally as great as that for engineering managers throughout industry today.

As in the strictly technical field, therefore, the opportunity literally clutches at engineers who are willing to fit themselves for the task to increase their income very greatly in the field of professional management work in the years immediately ahead.

Point 7. Last but not least, "the only 'missing ingredient' to retard climbing either of these paths to greater performance, service, recognition, and income is the will of the individual engineer himself."

In the 1940 Annual Report of the National Industrial Conference Board, Virgil Jordan, after a brilliant and penetrating analysis of the forces then plaguing a world going to global war, and after contrasting the totalitarian and the free enterprise philosophies, said that the essence of American philosophy can be put fairly in six short words: "Discover how and do it yourself."

There can be no more succinct way to tell electrical engineers of the confidence and of the responsibility which management reposes in them at this time than to say, again, "Discover how and do it yourself."

Self-development always has been the key to basic personal progress, especially in the United States.

The horizons of this country still are pushing out in every field of technical and managerial endeavor—and at accelerating rates, as can be demonstrated quantitatively by even the simplest factual analysis.

Their technical training and professional background give electrical engineers unique chances to go ahead under these conditions, whether they want to progress as a creative, technical individual performer or as a manager of the efforts of their fellow workers.

THE ENGINEER AND MANAGEMENT

There is one more point of view that seems deeply fundamental in any discussion of the place and relationships of engineers and management in today's complex industrial society. This is the engineer's responsibility to his manager, whether he personally is now in the ranks of creative, individual, professional workers, or is already on some rung of the managerial ladder but still reporting to another manager at a higher echelon.

This topic introduces an area that may be somewhat provocative. If so, it will be of value to explore it fully.

There are many types of programs that aim to spread understanding of engineering work among engineers. These functional educational courses and communication activities probably exist in all companies so it does not seem necessary to stress them further here.

In the last few years there have been many programs for better communication from the manager to his men, including communication from engineering managers to their engineers. While the level of achievement in these respects has varied from component to component, the objective has certainly been the same in many, many companies. Since human beings, including engineers, differ as widely as they do, we probably never will see the day when 100 per cent of managers in industry do a completely adequate job of informing every employee reporting to them so that each fully understands all company objectives, policies, and programs which are important to him. On the other hand, among the overwhelming majority of operating managers, this is the goal.

Frankly, however, much less has been heard about the other type of communication, namely, that from the engineer to his manager; and about the responsibility which he owes to the manager voluntarily to communicate upwards in organization channels as fully and frankly as he expects the manager to communicate in the opposite direction.

In talking to a group in his own company lately, the author stressed the fact that both individual and managerial work are important; and that an organization chart is intended to define the functional nature of a particular kind of work, and the way in which it is related to other work of the company, but definitely not to show the relative importance of the different kinds of work making up the over-all company activities. The following section is quoted from a set of notes on this subject:

"Neither the functional nature of particular work nor the organizational echelon at which it is best done are, as such, indicative of the relative 'importance' of particular kinds of work.

"Both managerial and specialist or technical work are needed and both are important.

"Both engineering and manufacturing work, or both marketing and relations or legal or accounting work, etc., are needed and both are important.

"Both purchasing management work and over-all manufacturing management work or both advertising management work and over-all marketing management work, are needed and both are important.

"Both a foreman's work and a general manager's work are needed and both are important.

"Both a foreman's work and a manual or clerical worker's work are needed and both are important.

"Hence, trying to give particular work, and especially so where it covers only part of primary function, special 'importance' by having the man responsible 'report to some one higher up in the management structure' is a sure route to unbalance, to dissension, and to arguments about the corresponding 'importance' of other specialties; and is to be avoided as a matter of organization principle."

The important point here is that trying to question whether the work of an individual engineer or the work of his manager is "more important" is like trying to answer the question whether one's heart or lungs are more important in the functioning and life of one's body. The answer is that a person is in a bad way if either one stops or fails to operate correctly and in harmony.

The point is that the same thing is true in any large modern industrial organization with respect to the work of

the individual engineer or other functional specialist and the work of his manager. Unless there is complete 2-way communication and co-operation, neither can function fully or effectively and competitively.

Everyone may not realize how deeply important the mutual nature and interests of these relationships are to all large modern industrial concerns; and indeed to the complex technical society of today. To make the point, the following paragraphs are quoted from a significant book in this field, Peter Drucker's "The New Society—The Anatomy of Industrial Order":

"The demands of the enterprise on the plant community and the demands of society and of individual are in harmony. The enterprise must demand that the individual assume a 'managerial attitude' toward his job, his work and his product; but that amounts to the same thing as society's demand for the individual's responsible participation as a citizen. The enterprise must demand the fullest utilization of the abilities and ambitions of its employees; its demand for people to fill supervisory and executive positions is practically insatiable, which means that the enterprise's interest and the demand for equal opportunities run parallel.

. . .

"The demands for a 'managerial attitude' on the part of even the lowliest worker is an innovation. There was neither room nor need for it in the pre-industrial order. It has come into being because mass production technology depends on social integration. Because of the 'specialization' which makes mass production possible—'specialization' which, as we discussed, is very different from the traditional division of labor—the mass-production technology demands an integration of the individual operation into a unified whole. It is this whole, the team, the pattern, the organization, which produces in the modern industrial system. This 'whole' does not exist in the individual operations themselves. It is a highly abstract thing. But at the same time it is necessary for the functioning and cohesion of this pattern, that the individual operator see it as a whole and understand his own function within it.

. . .

"The group to whom the 'managerial attitude' is most important is the group that is even more characteristic of the modern enterprise than the mass-production worker: the new industrial middle class of supervisors, technicians, and middle managers. If the efficiency of the enterprise depends on the attitude of the production workers, the very strength and functioning of the enterprise may well depend on the attainment of a 'managerial attitude' by the middle groups. For these groups are the organization itself, the nerve and circulatory systems of the enterprise.

"Unlike their ancestors, the skilled artisan, supervision, middle management, and technicians need no skill in the handling of tools or of materials. Their 'skill' is the ability to integrate. They have to organize the men under them into a productive team. They have to apply technical and scientific knowledge to the product and processes. They have to fit the work of their department into the work of the whole and to project the whole onto their own work. Top management can set the pattern, but middle management and supervision must live it.

. . .

"During the last few years American management has begun to realize the importance to the enterprise of this middle group and its attitude. But so far very few managements understand that of all the groups, the industrial middle class finds it hardest to see the whole and to understand its own function. The production worker deals at least with something tangible and immediate: a process, a motion, a product. He handles a strip of metal, pushes a lever, operates a machine. The middle group handles blueprints, pushes paper forms, and manipulates concepts and figures—all highly abstract. The worker works in a group of equals; the supervisor and middle manager, often the technician also, work by themselves. The worker can point to a part in the finished product and say: I put that one on. The man in the middle group can only say 'We,' without really being able to say who is embraced by this plural nor where he stands in this collective. The very group that ought most to have a 'managerial attitude' faces the greatest difficulties in attaining one.

"But why do we call this relationship to the whole the 'managerial attitude'? Would not 'understanding' be sufficient? The reason for my choice of the term 'managerial' is precisely that the social order of mass production requires more than intellectual awareness. Every member of the plant society has to be convinced that his own operation, however small, is vital to the success of the whole. He must be willing to assume responsibility for the whole. The old nursery rhyme that begins, 'For the want of a nail the shoe was lost,' and goes on to 'For the want of a nail the kingdom was lost' describes very well the structure of modern mass-production technology. Under modern integration there are no unnecessary or replaceable operations; therefore every single operation is essential. It also prescribes the attitude which the individual member of the society must take toward his own work. And this attitude which centers the whole in one's own work is the attitude of the 'ruler' rather than that of the 'subject'—it is a 'managerial attitude'."

This quotation from Mr. Drucker's profound book seems to pose a question which is as important to those handling their company's engineering work as individual creative technical specialists as it is to those who have moved from such type of individual work to that of the manager, endeavoring to achieve objectives through planning, organizing, integrating, and measuring the efforts and performance of their fellow workers.

The author, as one engineer who has chosen to make the transition from design to managerial work, followed the recent discussions, both within his own company and on a national scale, as to the need for some so-called unity organization among engineers. So much thought has been given to the specific aspects of that problem, that this article will not attempt to present a detailed discussion of the subject.

On the other hand, the word "unity" does bring up one

question: Irrespective of any need for "unity" among engineers as such, has adequate thought been given to the need for unity between the engineer and the enterprise—and indeed the society—of which he is a part?

Certainly if Mr. Drucker's thoughtful analysis is correct, any move which would result in separating the engineers as a unit group from the enterprise and its management would seem to have potentialities for danger to both that would warrant the most profound examination. In contrast, as Drucker indicates, the need for unity between the engineers and all other participants in organizations as complex as modern corporate enterprises is so clear as to be beyond dispute. Hence, one possible field for future specific thought among those who have done such constructive work in this field is that, quite apart from any other activities which they may have under way, there is some pioneering to be done to help everybody concerned to find how best to integrate the efforts of the engineer with those of the manager—and indeed with those of all other employees—to make modern industrial corporations properly serve the society of which they are so important a part, and which expects and demands such a great deal from them.

NEW HORIZONS

To reiterate, there is a great dual opportunity and challenge for professional, technical engineers in today's complex industrial society. Like few others in industry, parallel paths open invitingly before each engineer: either that of the creative, individual engineer; or that of the manager both of engineering work and of other business functions and of enterprises as a whole.

This is what is meant by the title of this article, "New Horizons for Engineers." They are the engineer's to reach if he wants truly to stretch for them.

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Impact of the Atomic Energy Program on the Electrical Industry

G. W. THAXTON
FELLOW AIEE

Starting with a power requirement of 225 megawatts at Oak Ridge during the war, the Atomic Energy Commission's demands on the suppliers of power will be approximately 6,500 megawatts. How the problems raised by these unprecedented demands are being solved is a tribute to American engineering talents.

Never before in history has there been a growth of industrial power load to compare with that of the facilities provided in the atomic energy program. Beginning with the initial 225-megawatt (mw) requirement at Oak Ridge, Tenn., and the lesser demand at Hanford (Wash.) Engineer Works, it is expected that the completion of the expansion program authorized in 1952 will bring the total demand of all Atomic Energy Commission (AEC) facilities to approximately 6,500 mw. Naturally enough, such a build-up of power requirements has affected many parts of the electrical industry. Some of the effects will be discussed here.

First, consider the program in the three main stages of its growth, as follows: (1) Manhattan District, (2) Expansion Program of 1950, and (3) Expansion Program of 1952, noting the names of the power supplying agencies, the amount of load allocated to each, and the plans made for supplying such demands. Following that, the effects of the program upon the power supplying agencies themselves and upon the electrical and other manufacturers and other aspects of the subject will be discussed. Since the requirements of the gaseous diffusion plants are so much greater than those of other facilities operated by the Commission, greater emphasis will be laid upon that part of the development.

MANHATTAN DISTRICT

In the initial stage of the atomic energy program, the Manhattan District facilities were built and operated by the Corps of Engineers, U. S. Army. While the power requirements of these plants were considered large at the time, they fade into relative insignificance when compared with demands of plants built later. The larger of the

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two Manhattan District plants was constructed at Oak Ridge because of the availability in that location of the large amount of dependable electric power required for its operation and because the site there fulfilled substantially all of the requirements of the criteria established for the selection of a site. Even then, a generating plant of 238-mw capacity was built because of the necessity for minimizing possibilities of interruption of power and also to supply plant requirements for variable-frequency current. Subsequently, the original 225 mw supplied by the Tennessee Valley Authority (TVA) for Oak Ridge operations was increased to 300 mw due to changes and minor expansions in that plant. TVA was able to supply these enormous demands from its system by providing adequate transmission facilities and bringing to completion the ten dams and the large steam generating plant which they had under construction at that time. Bonneville Power Administration supplied Hanford from its interconnected system.

EXPANSION PROGRAM OF 1950—OAK RIDGE AND PADUCAH

When the Congress authorized the next expansion of AEC facilities, it was decided that they would be split between Oak Ridge and a new site near Paducah, Ky., with 340,000 kw added at Oak Ridge and 1,000,000 kw to be required at the latter location. At that time power supply conditions in the areas contiguous to these two plants were rather tight. It was apparent that any such loads of such high load factors—and requiring continuity and stability of supply of the highest order—would have to be matched by new generating equipment. Accordingly, Oak Ridge was supplied from TVA's system by the building of additional transmission facilities, by the installation of additional generating units in existing plants, and by starting construction on the new Kingston plant in which it then was planned to install four 150-mw generating units.

At Paducah the situation was somewhat different in that the site selected lies just outside of what is considered ordinarily to be TVA's operating territory, and no privately owned company operating in the general area was interested in undertaking to supply by itself the 1,000 mw required by the plant. Originally, therefore, it appeared that TVA would be the only source of supply for the Paducah operations. However, five privately owned utility companies operating in areas adjoining that served by TVA formed a new company and offered to have this concern supply one-half of the load. Contracts were arranged thereafter under which TVA supplies 500 mw and the new company, Electric Energy, Incorporated, (EEInc) supplies 500 mw.

To carry out its agreement, TVA designed and began construction of its Shawnee plant, to be composed of four 150-mw generating units and EEInc designed and began construction of its Joppa plant of four 161-mw units. To provide interim and back-up power supply TVA built 154-kv lines from its Kentucky Dam generating plant and also from a connection at Martin, Tenn., with its main interconnected system. Likewise, EEInc built a 220-kv line to Cahokia, Ill., where it is connected to the system of Union Electric Company of Missouri and through it with the interconnected systems to the West. This line also is connected to the systems of other sponsoring companies at and through a substation at an intermediate point.

EXPANSION PROGRAM OF 1950—HANFORD AND SAVANNAH RIVER

The new facilities provided for Hanford Works in this expansion resulted in only a relatively small increase in the amount of power required. This is being supplied by Bonneville Power Administration from its system, which in the meantime has been considerably strengthened by the addition of new hydroelectric generating plants and new transmission and substation facilities.

A new plant was authorized to be built on the Savannah River between Aiken, S. C., and Augusta, Ga. This is referred to loosely as the "H-Bomb plant," and represents an investment of more than a billion dollars. The electric power for these facilities—insignificant by comparison with the requirements of the gaseous-diffusion plants herein referred to—will be supplied mostly by on-site generation, but an outside connection with the local power company will provide for approximately 20 per cent of the load.

EXPANSION PROGRAM OF 1952—GASEOUS DIFFUSION

Late in 1951 consideration was begun of the possibility of further expansion of AEC gaseous-diffusion facilities. Much study was given to the impact of such a program upon the economy of the nation with particular reference to: (1) the ability of manufacturers to produce the required equipment; (2) the availability of controlled materials and others in short supply; and (3) the availability of manpower. Even before the expansion program was recommended to the Congress, conferences were held with manufacturers and with appropriate Federal and other agencies in order to secure information on these phases of the subject. It was the hope of all concerned that this new expansion program could be launched without disturbing either the already planned defense effort or the civilian economy. On the basis of the information secured and in the light of the urgency of the need, the request for funds was sent to the Congress in the spring of 1952. Legislation authorizing the expansion program passed the Congress in July 1952.

In order to achieve as fast a build-up as possible in the production of fissionable material, it was planned that new facilities would be added at the Oak Ridge and Paducah plants and that a third site would be sought at which to build a plant requiring approximately 1,800 mw of power.

Power for the new facilities at Oak Ridge will be supplied entirely by TVA and the increased load at Paducah will be supplied 75 per cent by TVA and 25 per cent by EEInc. To meet the new demands upon its system TVA will add five 180-mw units to the Kingston plant, two 180-mw units to the Colbert plant, six 150-mw units to the Shawnee plant, and will build two new generating stations, the John Sevier plant with two 180-mw units and the

Gallatin plant with two 225-mw units. In order to supply the additional 235 mw assigned to EEInc, that company will install two additional 161-mw units in the Joppa plant. In the case of both suppliers, additional transmission and substation facilities will be constructed to provide for the delivery of construction, interim, permanent, and back-up supply to the AEC facilities.

It may be interesting to consider briefly some of the factors involved in selecting a site for the new plant. In the first place criteria were adopted to be used as a basis for deciding upon a proper location and these were given to the firm of consulting engineers employed especially for the task of investigating possible sites. Since it was known that new generating equipment would have to be provided to supply power for the operation, a great deal of consideration had to be given to finding an adequate and economic supply of fuel in relatively close proximity to a large supply of water. Naturally the criteria adopted covered other factors as well but in the end these things were predominant.

In addition to all of the other investigations carried out, special studies were made of proposals to build the plant: (1) in Texas where enormous deposits of lignite could be used; (2) in North Dakota where even larger deposits of lignite are available; (3) in several localities where gas and/or oil are available in large quantities; and (4) at some suitable location where gas turbines could be the prime movers in the generation of power.

It will be interesting to note that power supply for the new plant would have required the burning in one year of approximately 18,000,000 tons of lignite, 185,000,000,000 cubic feet of gas, or 1,300,000,000 gallons of oil. The problems involved in mining and processing such a large amount of lignite almost stagger the imagination. In this connection a thorough investigation was made of the Parry process for low-temperature carbonization of lignite to yield char as a solid fuel and tar as a chemical stock or as a possible liquid fuel. This is being used in a part of a new 300-mw generating station serving an Aluminum Company of America plant in Milam County, Tex. For several reasons, it was decided that use could not be made of this new process.

As to the possibility of using natural gas as boiler fuel, it was found that the consumption of gas for the generation of electricity for the plant would have exhausted the total known reserves in the state of Oklahoma in approximately 37 years, assuming that all gas in the state was to be dedicated to this use. The proposal to use gas turbines as prime movers in the generation of power was rejected when it was found that a 6,000-kw machine was the largest gas-turbine electric generator in use in this country and that one of 15,000 kw is the largest being designed by American manufacturers. In the final analysis the site was selected on the basis of the use of power from coal-burning steam-electric generating plants. To meet the requirements there seemed to be no better location than in the industrially crowded Ohio River Valley.

As already noted, there was no existing surplus which could be called upon to supply 1,800 mw of power for this new plant. Furthermore, the undertaking was too large to appeal to any one company. Accordingly, a new company was formed by 15 privately owned utilities operating in the same general area. This company, the Ohio Valley Electric Corporation (OVEC), now is building two generating plants; one near Madison, Ind., with installed capacity of 1,200 mw and the other near Cheshire, Ohio, with 1,000 mw. Selection of the sites for these power stations presented problems of substantial magnitude, involving, as it did, the locating and arranging for mining of the approximately $7^1/_2$ million tons of coal needed per year, and the placing of the plants in relation to the AEC facilities and the source of coal so as to achieve the most economic fuel cost per kilowatt-hour delivered to AEC. As would be expected, therefore, the sites selected were chosen after exhaustive studies of the many factors involved.

Power from these new generating plants will flow to AEC Portsmouth Works over 330-kv transmission lines interconnected and fully integrated with the large systems in the surrounding areas. Construction, interim, and back-up power supply for Portsmouth will be supplied from the systems of the sponsoring companies, interim supply of 465 mw being provided for. The 138-kv lines being built into the area to supply construction power will be incorporated into the permanent facilities to provide interim and back-up power.

MAGNITUDE AND NATURE OF AEC LOADS

Now that the major steps of the development of the program have been outlined, and the immediate plans of power suppliers to provide for these great new loads have been noted, consider additional aspects of the program's impact upon the electrical industry and upon our economy. First, it will be noted that, upon completion of the facilities provided in the 1952 expansion program, power for AEC Oak Ridge, Portsmouth, and Paducah operations will be supplied as follows: 735 mw by Electric Energy, Incorporated; 1,800 mw by Ohio Valley Electric Corporation, and 2,935 mw by Tennessee Valley Authority. Added together, these loads together with appropriate reserves amount to approximately the total capacity of all new generating units installed in the United States during the year 1952. Furthermore, the total energy delivered to these three plants in a year of full-scale operation will equal approximately the total energy consumed in 1952 in the states of Kentucky, Tennessee, and Ohio, and will be more than 10 per cent of the total consumption in the United States in that year. In fact, AEC has become the largest purchaser of electric power in this country and possibly in the world.

From several standpoints, the AEC loads are noteworthy. In the first place, sufficient synchronous condensers and static capacitors are used at each of these installations to correct the power factor of the power delivered to very near 100 per cent. Then, too, AEC equipment is so designed as readily to be operated to produce an annual load factor approaching 100 per cent. Furthermore, contracts through which the service is provided contain provisions designed to protect the power supplier against loss in event that the operation of AEC facilities is discontinued prior to the expiration of the term of the contract.

Even the generating stations being built to supply permanent power for the Commission's facilities are the largest in the world. OVEC's Kyger Creek plant will have 1,000 mw in five units; OVEC's Clifty Creek, 1,200 mw in six units; EEInc's Joppa, 966 mw in six units; TVA's Shawnee, 1,350 mw in ten units; and TVA's Kingston, 1,400 mw.

The magnitude of the values involved even has caused the coinage of new terms and the utilization of others which previously have been seldom used. As an example, kilo-megawatt is used to designate 1,000,000 kw and is abbreviated kmw. Likewise, kmva denotes 1,000,000 kva and kmwh, 1,000,000 kilowatt-hours.

As far as the three plants referred to are concerned, reference is made to a total annual power bill amounting to more than $180,000,000 (180 megabucks, if you please). When it is considered that 1 mill per kilowatt-hour on the total energy used by these facilities in a year of full-scale operation is equivalent to more than $45,000,000, the search for all possible economies can be understood. Even one which will save a fraction of a mill per kilowatt-hour is of great importance.

NEW OPERATING CONCEPT

UNDOUBTEDLY, the development of this program has brought a new operating concept to the power suppliers. Here they are dealing in each of these three plants with the largest industrial load ever served at one location. They are having to supply this service with a degree of reliability—freedom from interruption and freedom from fluctuation of frequency and voltage—much greater than usually is called for in service to industry. Even a very short interruption or other variation from normal may cause under certain conditions some of the large motors to stall and once started, this may continue until the entire plant is disconnected from the power source. In that case it is not alone the cost of restoring the facilities to production with which we are concerned but also the loss of product which the disruption entails. This situation becomes very involved by reason of the fact that the total connected motor load adds up to such a large percentage of the total kilowatt capability of the generating plants directly connected to the AEC facilities. Compensating for this, in a measure, is the fact that AEC is able to offer loads of unusually high power factor and load factor.

In order to provide service of this size and character, power suppliers have had to make tremendous investments rapidly in new plants and facilities, OVEC and EEInc together spending well over 0.5 billion dollars and TVA slightly less. Even though each of these agencies was proceeding with the expansion of its facilities under carefully planned system development programs, based upon all the accepted methods of load forecasting, these had to be ignored very largely when they undertook to serve the Commission's facilities.

It was necessary to build generating stations in locations far removed from the normal load centers of the power system and to build others at points within the service area of the agency at locations where plants would not have been built under normal growth conditions for many years to come. Both the Shawnee station of TVA and the Joppa station of EEInc are on the outer edges of their owners' respective service areas. Transmission lines have been built in locations not called for under conditions of normal growth and the operating voltage level of new lines, as well as that of existing lines being rebuilt or reinsulated, has been chosen to match that which would have been required many years hence.

LONG-TERM POWER SUPPLY CONTRACTS

IN ORDER to secure these enormous supplies of power on what is virtually a cost basis, the Commission has entered into long-term contracts with the power suppliers most of which have terms of 25 years from the beginning of full-scale operation. While providing for delivery of power on the basis of cost plus a guaranteed return on a small amount of equity invested in the power-supply facilities, these contracts have provisions the purpose of which is to reduce the risks which the power suppliers run in making the large investments at the locations and times noted and under the circumstances involved. As to the private utilities OVEC and EEInc, the equity capital is limited to approximately 5 per cent of the total invested, the remainder being secured through long-term debt financing. It will be seen that the greatest risk assumed by the power suppliers comes from the possibility that the Commission's operations may be reduced or discontinued resulting in the cancellation of the contract prior to the expiration of its term.

In the event of cancellation by AEC during the early years of these contracts, more than 4 years would be required before the capacity made available from these stations could be utilized fully without displacement of other plants even if fairly optimistic load growth conditions prevailed in the areas involved. During these years additional transmission facilities would have to be constructed to carry the power to the locations where the new demand is developed. Construction of new power plants underway also might have to be suspended or curtailed in order that the load growth of the areas could be used to absorb the capacity released by AEC.

During the period of readjustment, the power suppliers must continue to make interest and amortization payments on indebtedness incurred to construct the plants, pay taxes, pay for station maintenance and stand-by costs, and pay the costs involved in cancelling coal supply contracts or extending the delivery schedules therein. These continuing fixed costs, for which no other income is available, must be provided for either through a gradual reduction in the Commission's power requirements or through the medium of a cancellation payment by the Commission. In the case of the private utilities, assurance of such financial protection is a prerequisite for them to obtain the financing required to construct the facilities; in the case of TVA, assurance of such financial protection is necessary since, by law, TVA must provide for regular amortization of its investment and is expected to earn a fairly regular return on that investment. The cancellation payments in the contracts with OVEC, EEInc, and TVA will permit those

supplier concerns to meet the fixed costs for specified periods of time.

With the large proportion of the private utilities investment provided by debt financing and all TVA investment provided by appropriations of funds by the Congress, it will be seen that the power suppliers could not afford to undertake to sell power to the Commission at rates amounting practically to the cost of production and delivery unless protection of this type is afforded.

EFFECT ON MANUFACTURERS

Now a word about the impact of the program upon the electrical and other manufacturers who have been called upon for the development and production of equipment which this rapid load growth has made necessary. In the first place, it should be understood that the requirements of the atomic energy program have been one of the causes contributing to these developments but not necessarily the only cause thereof. Perhaps the program has affected the timing more than the nature of the advances which have occurred.

Reference already has been made to the new higher voltages adopted for transmission of power to AEC facilities, it having been noted that power to the Portsmouth works would be transmitted at 330 kv. Up until just recently when the American Gas and Electric Company placed its first 330-kv line in operation, the highest voltage in use in this country had been that of the Hoover Dam–Los Angeles lines operating 287 kv.

This stepping up of the transmission voltage to this new level has affected principally manufacturers of (1) oil circuit breakers, the interrupting capacity of which has had to be increased to a value high enough for the service required, and (2) transformers, where considerable impetus has been given to the development of larger and more efficient units.

One manufacturer said that they had worked approximately 3 years on the engineering and design of a 330-kv breaker to have 15 million kva interrupting capacity. This was set aside when it was learned that, because of the tremendous amount of generating capacity connected to the network from which the Portsmouth supply will be taken, breakers of at least 25 kmva would be required.

The shifting to the larger size and higher voltage transformers created special problems for some of the manufacturers. One instance is known where, after a 100-mva 154-to-14-kv transformer had been designed and built, it was necessary to assemble it in the test pit for testing because the new crane with sufficient headway and lifting capacity to move the transformer to the test pit in the usual way had not been completely installed.

The story of the developments in the manufacture of steam-turbine generator units is worthy of note. It seems that except in cases of duplicate machines going in the same plant, almost every new large unit placed in operation today is larger, uses higher working pressures, or operates at higher temperatures than any previous unit. To meet the tremendous demand for new equipment, the steam-turbine generator manufacturers have added substantially to their manufacturing capacity so that, upon completion of the planned additions to their plants, they now will be able to deliver almost twice the kilowatt capacity that they delivered 4 years ago. Whereas only approximately $6^1/_2$ kmva of new generating equipment was placed in service in 1952, it is expected that 12 kmva will be installed in 1955. Of this total 26 per cent will go into plants supplying permanent, interim, and back-up power to AEC facilities. Edison Electric Institute July 1953 survey shows 23 per cent more capacity scheduled for shipment in 1953 than in 1952.

The boiler manufacturers have kept up with the procession, greatly expanding their manufacturing facilities in order to provide the larger steam generators to be operated at higher pressures and temperatures than were used formerly. Recent articles in technical magazines have described a new generating unit which will operate at 4,500 pounds throttle pressure and 1,150° temperature with double reheat, for which great claims are being made.

In order to have maximum assurance that the availability of power supply would match the completion of AEC's new facilities, it was thought advisable some months ago to arrange for a priority rating for generating units associated with the supply of interim, permanent, and back-up power for AEC operations. Subsequently, this rating was applied to 73 units, most of which are scheduled for commercial operation during 1954.

CONCLUSION

Now that so much has been stated concerning the impact of the atomic energy program upon equipment, facilities, and the state of the art, this article would not be complete without giving some attention to the very important part that engineers have played in these tremendous developments. They are the ones who, in the end, have had to make the thing "tick." While the scientists, physicists, chemists, and mathematicians have formulated the theories, proposed the processes, and forecast the outcome and end-products of proposed actions (and they shall not be without the encomiums justly due them for their great accomplishments), it nevertheless has fallen to the engineers to design and manufacture the required new equipment and to design, build, and operate the new plants and facilities. Needless to say, they have met the challenge and have pushed forward to new frontiers in so many lines of endeavor connected with or affected by the program. Accordingly, it is appropriate that high praise be given to all engineers (civil, mechanical, electrical, or whatever their specialty) who have had any part in the development, including those in consulting engineers' or contractors' organizations, those employed by the manufacturers, by the power suppliers, and by AEC. Similarly to be praised are the consulting engineering and contracting firms, the manufacturing and the public utility companies, and the Government agencies that have been engaged in this enterprise.

In conclusion, based upon the results achieved in this program, we can be encouraged to believe that no matter what earth-shaking problems arise in the future, the engineers of the nation will be able to meet all of the demands placed upon them.

The Decilog: A Unit for Logarithmic Measurement

E. I. GREEN
FELLOW AIEE

Difficulties resulting from extension of the decibel are discussed, logarithmic measurement is considered, and the term "decilog" is suggested as a supplement to the decibel.

CURRENT concern over the decibel prompts further scrutiny. To start with, a brief retracing of history will serve to bring out certain points important to the subsequent discussion. The idea of using a simple unit based on the common logarithm of power ratio as a yardstick for the distortionless measurement of telephone transmission originated with R. V. L. Hartley.[1] Such a unit, then named a "transmission unit," was adopted in 1924 by the Bell System. It was chosen so as to be nearly the same size, and usable in the same way, as the previous "mile of standard cable."[2]

Four years later the International Advisory Committee on Long Distance Telephony in Europe adopted the "bel" and the "neper" as alternative units for transmission measurement, and the transmission unit was rechristened the "decibel."[3] While the bel was the unit officially selected, the decibel has proved so much more convenient in size that the bel is now all but forgotten. The original concept of the decibel was simple. It was regarded as a division of the logarithmic scale, or in other words a logarithmic unit, such that the number of decibels corresponding to the ratio of any two powers P_1 and P_2 is equal to 10 $\log_{10} P_1/P_2$.

Through the years the decibel has found wide utility in communication and allied fields. The logarithmic expression is handy for several reasons. It is simpler to say that two powers differ by 50 db than either to say that they bear a ratio of 100,000 to 1, or to employ the exponential expression that one is 10^5 times the other. Above all, it is far easier, when combining transmission losses and gains, to add or subtract decibels than to multiply or divide the corresponding ratios. In addition, the size of the decibel is such as to result in easily manageable numbers of decibels for most computations. Further, the decibel has been useful in acoustical work because the response of the ear to sound intensity is a logarithmic function, and in fact the minimum change of intensity that the ear can detect is about one decibel.

EXTENSION OF THE DECIBEL

So useful has the decibel proved that scientists have been lured into extending its meaning, in some instances with a degree of reason, but in others quite improperly, in ways not conforming to the original definition. It was rather natural to extend the decibel to quantities related to power, namely voltage or current. Thus the number of decibels corresponding to a scalar current ratio I_1/I_2 or a scalar voltage ratio V_1/V_2 was taken as $20 \log_{10} I_1/I_2$ or $20 \log_{10} V_1/V_2$, respectively. Initially the decibel was applied to voltage or current ratios only in cases where these ratios are the square roots of the corresponding power ratios (i.e., where the impedances involved are equal), but it was gradually extended to scalar voltage and current ratios where this was not the case, a practice which has received the sanction of defining bodies, provided specific statement of conditions is given.[4] The decibel has been also, with approval of defining bodies, extended to apply to ratios of sound intensity (using $10\times\log_{10}$) and ratios of sound pressure and sound particle velocity (using $20\times\log_{10}$).[5] In fact, the decibel has become associated in the minds of the public with sound intensity level.

PRESENT DIFFICULTIES

WHILE even this extension of usage tended to introduce a certain amount of confusion, the confusion has in recent years become worse confounded as engineers have discovered that a logarithmic unit is convenient for expressing ratios of quantities entirely unrelated to power, and in default of an accepted unit for this purpose have pirated the decibel. A number of people are beginning to use the decibel as a yardstick for ratios of values of length, or size, or frequency, or impedance, or permeability, or dollars, or whatnot. Usually they ignore the basic difficulty which arises from the fact that decibels are equal to 10 times the logarithm of the ratio when applied to power-like quantities and 20 times the logarithm of the ratio when applied to voltage-like or current-like quantities. Hence in using the decibel for other kinds of ratios some people have made it always equal to 10 times the logarithm, some always 20 times, and some have used either 10 or 20 times according to whatever similarity they found or fancied to exist between the quantity under consideration and power, voltage, or current. Such difficulty in extending the decibel might have been avoided by defining it more fundamentally, without a special relation to power ratio, but that is just hindsight.

The confusion and ambiguity arising from this extension of the decibel to magnitude ratios of any kind has been a matter of growing concern to defining bodies and others. Vigilance and deprecation, however, have only partially arrested the trend. To illustrate the chaotic state of affairs which now exists, the American Standards Association (ASA) *C42* Subcommittee on Definitions of Com-

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munication Terms over the last few years has received numerous letters divided about equally between pleas for extension of the decibel to new applications and pleas for stricter limitation of its meaning. Like any group of lexicographers, the subcommittee has tried neither to walk too far ahead of usage nor to lag too far behind. It is apparent, however, that a more positive approach is needed.

PROPOSALS

There have been several proposals for taking care of this situation. M. W. Baldwin, Jr., and R. E. Graham, in an unpublished memorandum dated March 24, 1947, suggested that the name "decilu" (derived from decilogarithmic unit) be employed to express the ratio between two values of any quantity, the number of decilus being equal to ten times the common logarithm of the ratio. Subsequently J. W. Horton, in two articles on this problem,[6,7] has suggested that the name "logit" be used for essentially the same purpose. (See also reference 8.) Mr. Horton approaches the matter from a somewhat different point of view, preferring to consider the logit as a "standard magnitude ratio" having a value of $10^{0.1}$ (i.e., a ratio of 1.25892+). This is a perfectly tenable concept. Yet, regardless of how the term is defined, computations are most conveniently made with logarithms. Hence it seems to be simpler in practice to think in terms of a logarithmic unit. In any case the number of logits turns out to be ten times the common logarithm of the ratio.

Others have proposed that the "brigg" be defined so that the number of briggs is equal to the common logarithm of any magnitude ratio, and the "decibrigg" one tenth the size of the brigg (i.e., number of decibriggs equal to ten times the common logarithm of the ratio). Still others have suggested that the name "decade" be employed (incorrectly) in the same sense as proposed for brigg. While a number of people have subscribed in principle to one or another of these proposals, none has achieved more than limited use. There is available also the rather cumbersome and imprecise expression that two values which bear a ratio of about 10 to 1 differ by an order of magnitude.

A canvass of a fairly large number of representatives of various technical organizations indicates rather widespread (though not unanimous) agreement that a new logarithmic unit, applicable always in just the same way for expressing the ratio of two values of any kind of quantity, is needed. (The small minority divides about equally between those who think that the decibel as now defined is adequate, and those who think its meaning should be extended to permit application for ratios entirely unrelated to power.) There is good agreement, too, that the magnitude of the new unit should be such that the number of units equals ten times the common logarithm of the ratio.

Why then have none of the proposals to date gained currency? The answer seems to be that defining bodies are reluctant to accept a new term until it has achieved fairly general usage, while in the case of anything as fundamental as a unit of measurement, most people want the stamp of authority before accepting something new. The solution obviously lies in the same procedure which has been used in the past for many kinds of units, namely, official authentication by national, and preferably international, authorities as a warrant for general use. While defining bodies are usually best advised to let usage develop naturally, new units are an important exception since early standardizing action can prevent imprecise and inconsistent usage.

It is proposed, then, that a new unit be standardized to represent the ratio of two values of any quantity, and that the size of the unit be such that the number of units equals ten times the common logarithm of the ratio. There remains the choice of a name for the new unit. The name "logit," which has been under consideration, is open to objection. The term logit has been used in statistical work as an abbreviation for "logistic unit," which is employed for linearizing the logistic function.[9] Of greater moment, however, is the fact that the logit has been defined as a standard magnitude ratio. This concept has proved troublesome to engineers who have through the years become accustomed to using the decibel and thinking of it as a logarithmic unit. Incidentally logit logically should be pronounced with a soft g, and no matter how pronounced, is not very euphonious. The name decibrigg has considerable merit, but in abbreviation would surely be confused with the decibel.

THE DECILOG

In view of the failure of names thus far proposed to achieve wide acceptance, it seems better to try another one. The name should be reasonably euphonious and should lend itself to a simple and unmistakable 2-letter abbreviation. Search of various possibilities has led to the name "decilog" (suggesting a logarithmic unit one tenth the size of the unit employed for logarithms to base 10 or, in other words, a new logarithmic basic equal to the tenth root of ten). It turns out that the name decilog has been independently derived by several people (though not heretofore published). According to available information, it was first proposed by N. B. Saunders in 1943, subsequently by A. G. Fox in 1951, and most recently by the writer. This coincidence suggests that the name is a happy choice.

For an abbreviation of decilog, "dg" is proposed. This avoids any confusion that might exist, if "dl" were used, between "ell" and "one." After all, abbreviations are a sort of arbitrary shorthand, where catch-as-catch-can rules. As extremes, note oz. for ounce, Rx for recipe, etc. The use of the initial and final letters to form an abbreviation has many precedents, as, for example, bn. for battalion, Md. for Maryland, and such everyday compactions as ft, yd, qt, hr, yr, etc. Note also the analogy to stock ticker practice, where SY stands for Sperry Corporation, etc.

The similarity of the name decilog and its 2-letter abbreviation to decibel and db, respectively, are believed to be assets which should facilitate understanding and ready acceptance. It is not intended that the new unit replace the decibel. In fact, the basic usage of the decibel

is so ingrained as to preclude change, except possibly over a long interval. The proposal is to retain the decibel for present legitimate uses, and employ the new unit to supplement it. Though the problem of transmission-loss computation which gave rise to the decibel is somewhat unique, the demands for extension of the decibel and the increasing use of logarithmic measurement in various fields suggest that many applications will be found for the decilog.

In order to give the decilog official status, the Subcommittee on Communication Terms has approved a definition of it for inclusion in ASA *C42*. Because of the limited usage which has been made of the term logit, that term is included also. The definition is as follows:

> *Decilog* (dg): The decilog is a division of the logarithmic scale used for measuring the logarithm of the ratio of two values of any quantity. Its value is such that the number of decilogs is equal to 10 times the logarithm to the base 10 of the ratio. One decilog therefore corresponds to a ratio of $10^{0.1}$ (i.e. 1.25892+).
>
> Note: The decilog is intended to supplement, and not to supplant, the decibel.

LOGARITHMIC UNITS

Reference to the decibel and the decilog as "logarithmic units" may be deserving of comment. A unit is by definition a quantity adopted as a standard for measuring other quantities of the same kind. As R. V. L. Hartley has pointed out,[1] the decibel does not measure a power ratio. If it did, decibels would have to be multiplied and divided, not added and subtracted. The decibel in its fundamental sense measures the logarithm of a power ratio; similarly the decilog measures the logarithm of any ratio. In each case the magnitude of the unit is the logarithm of $10^{0.1}$, taken to the same base as the logarithm which is to be measured. Although it is convenient when using decibels or decilogs to employ common logarithms, any arbitrary base could be used, provided it is the same for the measuring unit and the logarithm to be measured.

LEVELS

Closely related to the matter of a logarithmic unit for expressing magnitude ratios is the need for a logarithmic way of expressing the ratio of a magnitude to some standard magnitude of the same quantity, or in other words, expressing the level of a quantity with respect to some reference level. In the case of the decibel certain abbreviations have become current for this purpose. Thus dbm expresses the power level in decibels referred to 1 milliwatt and dbw referred to 1 watt. Such abbreviations are convenient, and similar ones will doubtless be employed with the term decilog. When in doubt, a foolproof way of designating levels is to show the reference level as a subscript following the abbreviation dg. Thus 40 $dg_{(1\ gauss)}$ would signify a level of magnetic flux density 40 dg above 1 gauss, i.e.,10,000 gausses.

CONCLUSION

In summary, it is proposed that a new logarithmic unit, christened "decilog" and abbreviated dg, take its place alongside the decibel. The new unit differs from the decibel in that it may be applied to any ratio whatever in an invariant manner. The fate of this term, like that of all new words, will be decided, not by standardizing bodies, but by the extent to which a need is satisfied.

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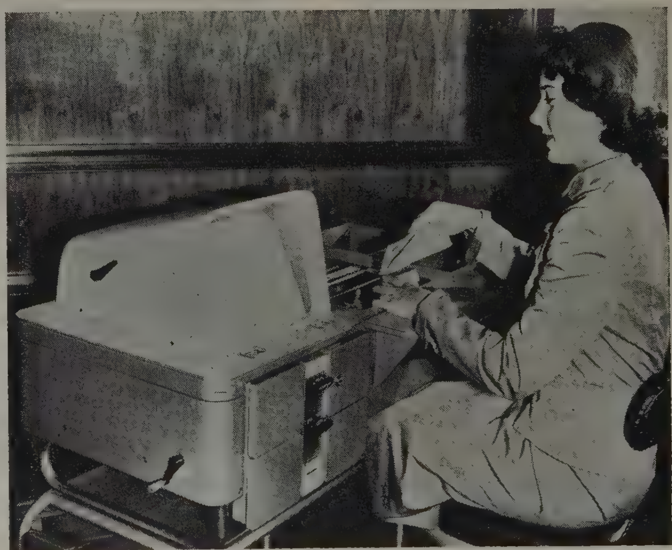
Microfilming Machine



A low-cost microfilming machine for office use which combines recording and reading in one compact, portable unit has been announced by Burroughs Corporation and Bell and Howell Company. The machine, named the Micro-Twin, will record documents smaller than bank checks up to single sheets 11 inches wide and 3,700 feet long, photographing both sides. A system of mirrors is used to record the face and reverse sides at the same time. The machine will photograph documents intermixed in size just as fast as they can be fed into it. The dual-purpose lens projects a life-sized image of the document on the reader. The Micro-Twin also may be used to reproduce facsimiles of any filmed document without requiring the facilities of a dark room. High-speed automatic feeding of documents is made possible with an Acro-Feeder attachment which features an adjustable micrometer control. This automatically stops the feeding when documents overlap or are thicker than the micrometer setting. Each document takes its own picture as it passes the camera lens. The leading edge of the document turns on the lights to expose the film and the trailing edge turns it off

TEN FOUNDING FATHERS OF THE ELECTRICAL SCIENCE

IV. ALESSANDRO VOLTA

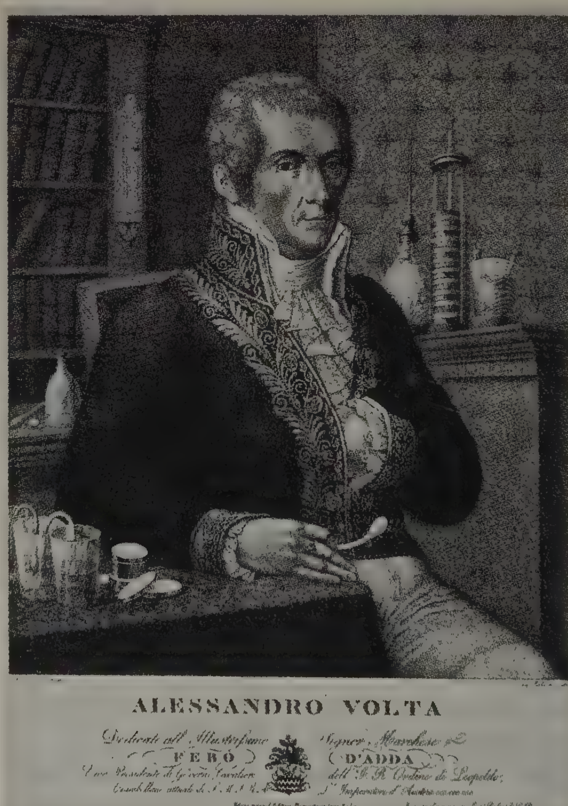
and the electric generating cell

BERN DIBNER
FELLOW AIEE

Alessandro Volta, a physicist whose experiments in contact-electricity led to the discovery of the voltaic cell and provided a practical source of continuous electric current, was responsible for the forward move that brought electricity from a plaything of the curious to a most important tool in the hands of mankind.

THE SCIENTIFICALLY FRUITFUL 1700's ended with electricity still in the form of electrostatic discharges, small ones in the laboratory, shattering ones in the form of lightning. At the very end of the century there was introduced energy in a new form, electricity from a chemical source—the electric "pile" or battery conceived by Alessandro Volta.

Beginning his electrical investigations in 1762, Volta improved the electric equipment of his day by introducing the electrophorus, a kind of reservoir of electricity. It was one of the first electric machines that operated by electrostatic induction or "influence" rather than by direct electrostatic generation. The device consisted of a plate of resin placed between an upper and lower plate of metal. The upper plate was lifted by an insulated handle and the resin was charged by being struck by a silken scarf. When the upper plate was laid on the resin, grounded by being touched by the experimenter's finger and then removed, it became charged by induction. This device brought Volta's name before the attention of electrical experimenters everywhere. He invented the condensing electroscope; with it minute quantities of electricity could be detected and it was therefore very useful in the investigations that led to the invention of the pile. It was the publication of the operation of this condenser in the transactions of the Royal Society in 1782 that won him the society's Copley Medal in 1794.



Drawn by R. Focasi, engraving by Luigi Rados, Milano, 1828, inscription condensed

Volta was investigating the recently announced phenomenon of "animal electricity" discovered by Luigi Galvani, professor of anatomy at the University of Bologna. Galvani, a shy and retiring scholar, had noticed, while dissecting a frog, that a discharge from a neighboring electrostatic generator had caused the legs of the dissected frog to jerk. He thereupon tried to trace the relationship of the charge and the muscular action. "While one of those who were assisting me touched lightly and by chance the point of his scalpel to the internal crural nerves of the frog, suddenly all the muscles of its limbs were seen to be so contracted that they seemed to have fallen into tonic convulsions." In 1791 he published his observations and theory, one of science's key discoveries, in the *Transactions* of the Bologna Academy of Sciences.

Galvani sent a reprint of his paper to a few of his scientific colleagues, including the professor of physics at Pavia, Volta. In a revolutionary period of the world's history, this paper with its startling significance, aroused the interest of scientists everywhere. Volta concurred in the general theory proposed by Galvani and proceeded to repeat the experiments. As these experiments progressed, Volta became convinced that the true electric source lay not in the tissues of the animals investigated but came from an outer source, the contact of dissimilar metals. The controversy between the two schools

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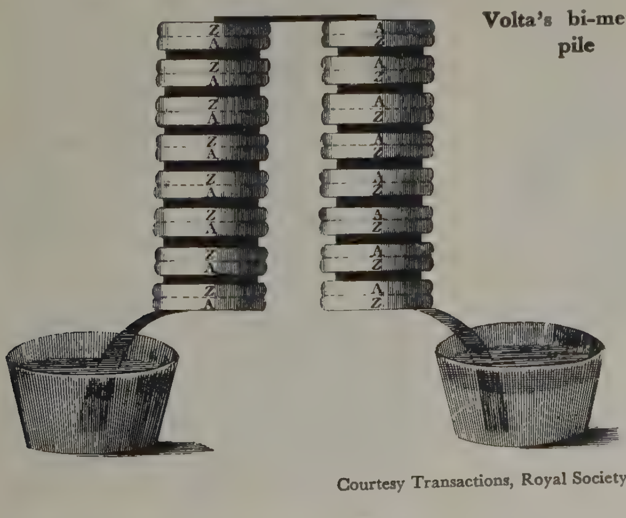
of thought was resolved when Volta disclosed the nature of the electric cell in a letter written from Como on March 20, 1800, to Sir Joseph Banks, president of the Royal Society of London. In this letter Volta described his new apparatus which he compared in action to the Leyden jar.

Volta observed that the results produced depended on the kind of metals used in combination. He therefore arranged the common metals into a series and using rubbed rods of glass and of resin in order to obtain positive or negative electricity as a reference, Volta combined these metals and established which combination produced the strongest positive or negative charges. Some combinations produced negative, some positive charges. He therefore became convinced that in kind and degree the result depended on the *relative* arrangement of the mating metals in a series in which zinc proved most positive and graphite most negative, with lead, tin, iron, copper, silver, and gold, between those two. Volta thereby could anticipate the strength of a charge in the relative position of the metals in this (electrochemical) series; from this he derived his "law of successive contacts." In its final form, Volta proposed a stack of elements consisting of disks of silver and zinc separated by brine-soaked cloth or paper. Thirty such elements formed this pile and caused a flow of sufficient continuous current to be perceptible to a person touching the outer elements of the pile. A modification of the device was to arrange a row of cups containing weak acid or brine; into each cup a zinc and silver plate was placed; alternate elements were connected by metallic strips; this Volta termed his "crown of cups." This arrangement avoided the weakening of the flow of current that followed when the moisture (electrolyte) dried from the paper or cloth separators in the pile arrangement. He also found copper an improvement over silver in the set.

In his letter to Banks, Volta said that although the new source of electricity was weaker in character than the discharge from the Leyden jar, it did possess the great advantage of offering a *continuous* source of electricity. In fact, felt Volta, his pile of copper and zinc disks could supply an inexhaustible and constant electric flow. His letter states "this endless circulation or perpetual motion of the elastic fluid may seem paradoxical, and may prove inexplicable; but it is none the less real and we can, so to speak, touch and handle it" and "I found myself obliged to combat the

Volta's bi-metallic pile



Courtesy Transactions, Royal Society, 1800

Courtesy Burndy Library

Pastel drawing of Alessandro Volta made from life about 1815 attributed to Francesco Hayez

alleged animal electricity of Galvani, and to declare it an external electricity moved by the mutual contact of metals of different kinds." Since Volta was a physicist rather than an anatomist, the emphasis of his thinking had shifted from the physiologic elements to that of the metals.

This revolutionary contribution, one of the most brilliant gifts of the human mind, was recognized immediately for its true importance. Volta was invited to Paris to demonstrate his discovery before Napoleon. Experimenters everywhere now were afforded a source of constant-flow electricity. They found in these new devices a means of drawing electric current for hours instead of the erratic spark that came from the electrostatic generators or Leyden jars.

With this new instrument Nicholson and Carlisle in England decomposed water into its elements and determined the true volumetric ratio of oxygen and hydrogen. Sir Humphrey Davy, using a large voltaic pile, discovered potassium and sodium. He also drew an electric current from a 500-plate voltaic battery and caused two charcoal electrodes to burn with sunlike brilliance; in this way began electric illumination. With constant-flow electricity the electromagnet was formed by Arago and by Davy.

Succeeding generations of electricians, who best understood the magnitude of Volta's contribution, saw fit to measure electromotive force by the term "volt" as proposed by the International Electrical Congress meeting in Paris in 1881. In his eulogy of his colleague Volta, Arago wrote of the electric battery as "the most marvellous instrument created by the mind of man, not excluding even the telescope or the steam engine."

Submarine Cable for 100-Kv D-C Power Transmission

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MEMBER AIEE

A 100-KV D-C submarine cable, 60 miles long and weighing approximately 1,000 tons, has been laid in the Baltic Sea and will be used for transmission of about 20,000-kw d-c power between the mainland of Sweden and the Isle of Gotland.

The Gotland cable is a single-conductor mass-impregnated lead-covered paper cable with a copper cross section of 180,000 CM, an insulation thickness of 0.275 inch, two concentric lead sheaths, and steel wire armoring.

Due to possible overvoltages, this cable had to withstand a 425-kv impulse test.

For the Gotland cable, the solid-type paper cable was chosen, because it would have been too difficult a task to make and maintain an oil-filled cable for the 60-mile submarine stretch.

In the Gotland cable, the amount of oil used is low. A solid conductor containing no oil and an extremely compact insulation containing very little oil is used. Moreover, the water surrounding the cable has nearly the same temperature the year round. In the water the full load will not increase the temperature of the conductor by more than 8 C. Finally, the water pressure itself is utilized to exert an overpressure on the oil via the flexible lead sheath. Voids therefore will not be formed where the cable lies under deep water.

Two thin continuously extruded lead sheaths were used instead of one thick sheath. The risk of a simultaneous fault in both sheaths ought to be negligible, and, moreover, two thin sheaths are more flexible than one of double thickness and will transmit the hydrostatic pressure to the interior of the insulation better.

In the Gotland cable 40-micron papers were used near the conductor, followed by thicker tapes towards the sheath. A total of 100 tapes were used in making 7-mm insulation.

The cable is a single-core cable, intended to conduct the current only one way. The return current should go through the water. So that this current will not damage the lead sheath, the electrodes for the return current have been placed about 10 km from this cable and from a telephone cable, following the same route.

As the longest length of this cable weighed 600 tons, see Fig. 1, it was impossible to bring it down from the factory to the harbor, a distance of 2 miles, on a drum. A rather new scheme therefore was invented.

A roller track was laid from the factory down to the harbor, over the roofs of the factory, along a railway track, along streets, through tunnels, and over streets. The method was to draw the cable directly from the storage coil at the factory and down to the harbor and there immediately pay the cable into the laying ship.

Pullers, Fig. 2, placed at a distance of about 1,000 feet from each other, pulled the cable constantly night and day during the 4 days the paying in of the cable lasted.

The laying of the cable from the cable ship started for both submarine cable lengths from the shores and proceeded to the place at sea where a joint was made between the two lengths. The cable was laid at a maximum speed of 6 knots. During the laying of the cable from the ship, the dynamometer showed a steady longitudinal stress in the cable of 1 ton. On one occasion a stress of 3 tons was registered. Everything indicates that the cable after laying is intact.

Digest of paper **54-79**, "A Submarine Cable for 100-Kv D-C Power Transmission," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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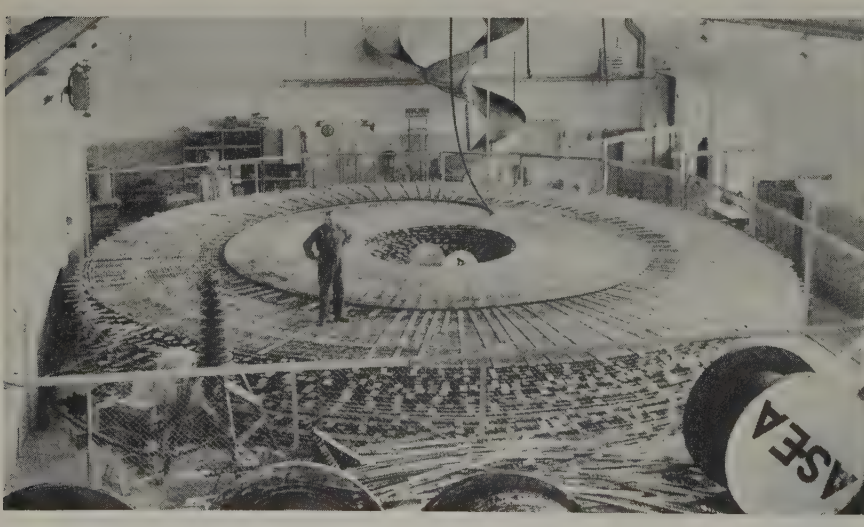

Fig. 1 (left). A 600-ton coil of cable. Fig. 2 (right). Cable being payed out by 12 electrically driven pulling devices directly from the factory into the cable-laying ship 2 miles away

Fundamentals of Flashing of Diesel-Electric Motors and Generators

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Flashing is one of the important considerations in the manufacture and operation of electric equipment for diesel-electric locomotives. Its importance has increased because of the large number of high-speed and high-powered road locomotives which have been put in service during the past few years. Minimization of these effects can be had by a better understanding of the basic causes of flashing.

EXAMINATION of a large number of motors and generators of different manufacture on high-speed diesel-electric locomotives has indicated that the machine which shows no evidence of flashing is an exception. Flashing may occur without any appreciable damage to a motor or generator or any interruption of service. Flashing also may be so serious that the locomotive cannot continue in service or a motor or generator has to be removed for repair.

It is the purpose of this article to examine some of the fundamental causes of flashing from both design and operating standpoints, so that better understanding may be had of how to minimize flashing and its effects.

Flashing has been considered by many persons as mysterious, because like lightning it occurs suddenly and often when least expected. There are several kinds of flashing. It is for this reason that the term "flashing" has been used in the subject of this article rather than "flashover." An arc or flash may occur where commutator bars are leaving the trailing edge of the brush. This, occurring suddenly, is certainly a visible "flash" even if it does not extend to any other part of the machine. Such an arc or flash at the brush edge may appear to be quite severe without producing an actual flashover between brushholders. A flash of light around the commutator commonly known as "ring-fire" also may occur. Ring-fire is the result of small arcs between one or more pairs of adjacent commutator bars. These arcs between bars usually are formed as the spaces between adjacent bars, short-circuited by the brush, leave the brush, and may continue for several revolutions. In cases of exceptionally high maximum volts per bar resulting from high voltage and a distorted field form, these arcs may form while the bars are between brushes. The apparent continuous ring of fire around the commutator is usually an optical illusion and is caused by the high peripheral commutator speed while these small arcs exist between certain bars. There also may be a flash or arc from the commutator or brushes to some adjacent grounded part of the machine due to creepage over an insulating surface.

The two most common kinds of flashing are the arcing at the edge of the brush and ring-fire. Neither one of these is usually very destructive in itself, but either one may develop into an arc extending over the surface of the commutator from brushholder to brushholder. This type of flashing is defined as a "flashover" and can be quite destructive if allowed to continue for even a fraction of a second.

Arcing at the brush edge is due to a current surge and actually is instantaneous bad commutation. Any arcing of this kind creates vaporized conducting material and if the heat of the arc is sufficient to vaporize enough material and ionize the surrounding air, the arc will grow in size and may result in a complete flashover. The instantaneous condition of bad commutation does not mean that the motor or generator is a poor commutating machine. Present-day diesel-electric motors and generators usually have excellent commutating ability over their entire range of operation under steady-state conditions. The instantaneous bad commutation which initiates a flashover is due to a sudden surge of armature current. Since there is a time lag in the commutating field magnetic circuit, the voltage induced in the coils short-circuited by the brush is not fully compensated for by the commutating field for a short period of time, resulting in instantaneous bad commutation.

The ring-fire kind of flash also may result in a complete flashover by an increase in the number of small arcs between bars until a heavy arc extends from brushholder to brushholder.

Oscillographic analysis of flashovers has proved valuable in determining the current and voltage variations that occur. Such analysis on locomotives in service, however, has not proved very fruitful due to the difficulty of obtaining flashovers when wanted. They seem to occur always at times other than when the oscillograph equipment is set up on the locomotive. Oscillographic analysis has been more profitable on the test floor where the severity of conditions can be increased until flashover does occur.

Fig. 1 is a tracing of an oscillogram of a flashover of a series railway motor produced by the ordinary circuit interruption and reclosing method. Connections were as in Fig. 2. The interruption was for 1/2 second. The conditions prior to the interruption of the circuit correspond to running at maximum speed in a weak field. The voltage

Full text of paper 54-45, "Fundamentals of Flashing of Diesel-Electric Motors and Generators," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Applications and Industry*, May 1954, pages 70–7.

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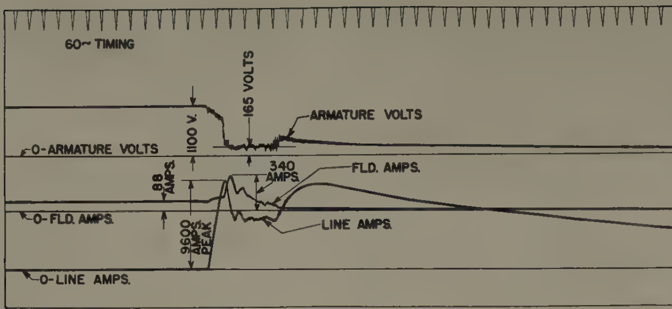


Fig. 1. A tracing of an oscillogram of a motor flashover which was produced by the current-interruption method

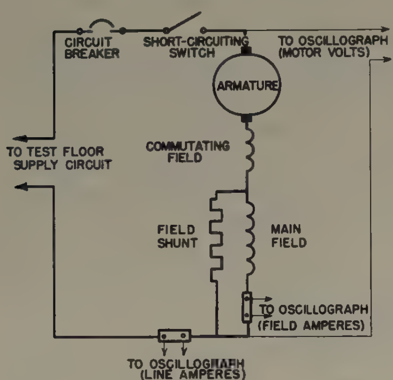


Fig. 2. Schematic diagram of the test circuit for producing motor flashovers

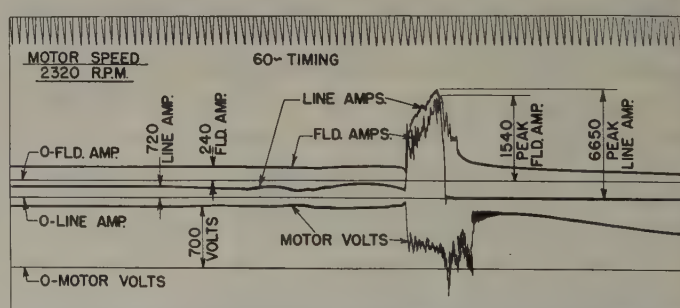
was 20 per cent higher than ever used in service at this field strength. This higher voltage was required even with the severe condition of circuit interruption for 1/2 second, in order to produce the flashover. When the circuit was reclosed, the line current rose very sharply and the flashover started in approximately 1/60 second. This is indicated by the beginning of the rapid oscillation of the field current and voltage traces caused by changes in the arc. The line current and field current continued to rise to peak values at which time the test-floor protective circuit breaker opened and the line current dropped to zero. The field amperes and terminal volts returned gradually to zero as the field current decayed. The terminal volts dropped to a low value during the flashover due to line drop of the supply circuit. The voltage to maintain the arc between brushholders was low as compared to what it was to overcome counterelectromotive force just before the flashover.

Fig. 3 is a tracing of an oscillogram produced on a series railway motor by lifting the brushes of one polarity from the commutator. This was done by attaching strong cords to the brushholder fingers and wrapping the brush shunts around the fingers so that both fingers and brushes would be lifted from the commutator. Two assistants were employed to pull on the cords. Since they did not pull exactly at the same time, there were irregular variations of line current for approximately 1/3 second before the flash started. The conditions prior to brush lifting were similar to those for Fig. 1 before interruption, and the general behavior of line current, field current, and terminal voltage during flashover was similar.

Fig. 4 is a tracing of an oscillogram produced on a series railway motor by suddenly throwing a small handful of thin copper slivers on top of the commutator while running. The running conditions again were similar to those of Fig. 1, before interruption, and the general pattern of the current and voltages was also similar.

Fig. 5 is a tracing of an oscillogram of a diesel-electric generator flashover with no overload protection except means for opening the separately excited exciter field at the beginning of the flash, and a circuit breaker in the driving motor circuit. Connections were as in Fig. 6. The flashover was produced by running the generator at full speed, no load, with the main field excited by its exciter to give approximately maximum volts, and then suddenly short-circuiting the main generator terminals through a low resistance. The behavior of the armature current, field current, and terminal volts is typical of a generator flashover produced by a surge of current. The duration of the arcing between brushholders can be noted readily by the rapid irregular variation of these three values. At the time the short circuit was thrown on, the armature current rose very quickly to an excessive value, at which the flashover took place, as shown by the sudden drop and irregular variations of the line current. The determining factor to start the flashover for the set of conditions used was the reaching of a fairly definite value of excessive current. The reason for the sudden drop of line current, is that most of the current between brushholders was flowing through the arc. It should be noted that this is just the opposite to what happens when a series motor flashes over. In that case, the arc current is included in the line current. The arc current in the case of the generator is not measurable because it flows through the armature and then from brushholder to brushholder across the face of the commutator.

The behavior of the generator terminal voltage was to drop suddenly as the current rose. As soon as the flashover became established, the measured terminal voltage was only that across the arc plus the drop in the field coils carrying line current.



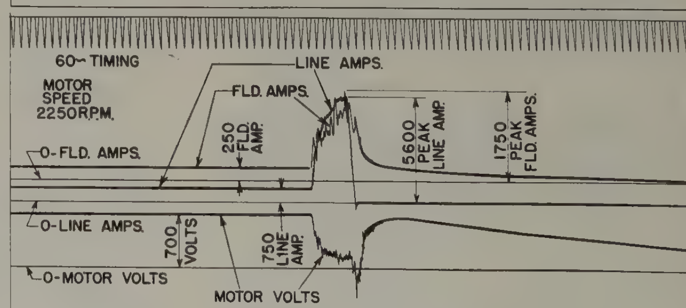


Fig. 3 (above). Tracing of oscillogram of motor flashover produced by brush lifting. Fig. 4 (below). Tracing of oscillogram of motor flashover produced by copper slivers thrown on the commutator

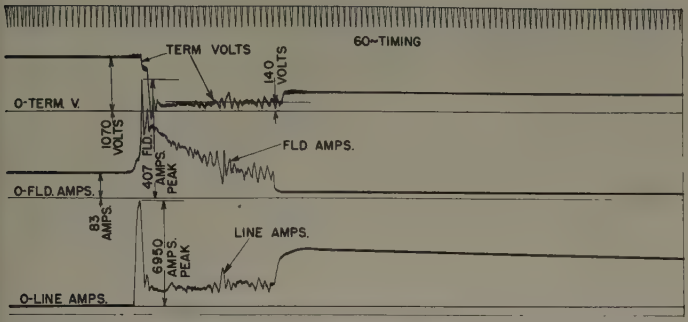


Fig. 5. Tracing of oscillogram of generator flashover produced by short-circuiting through resistance

The generator main-field current shows an induced rise co-ordinate with the initial rise in line current, but decreases in rate of rise as the line-current rate of rise decreases. Then when the flashover starts, the field current rises very suddenly again to a much greater peak due to excessive armature current and then oscillates while gradually decaying to the point where the arc goes out. If the peak value of induced field current can be taken as a measure of the rise of the armature current after the flash starts, as it may be before it starts, the value of the arc current is several times the indicated line current at the start of the flashover. This accounts for the potential destructiveness of such an arc if allowed to continue.

As will be seen from the oscillogram, the arcing lasted 22 cycles, or 0.37 second, which is a long time for a destructive arc to continue. In this case the commutator bar ends were badly beaded, the string band blackened with smoke, and brushholder castings pitted. The speed decrease during the flashover was practically negligible due to the large rotating mass of the driving motor.

These typical oscillograms of motor and generator flashovers produced by applying very severe conditions on the test floor give a picture of how the current and voltage values vary before, during, and after flashover. The exceedingly short time for the flashover to start and extremely high values of current obtained are the outstanding features.

OPERATING CAUSES OF MOTOR FLASHOVERS

THERE ARE many reported causes of motor flashovers in service, although in many cases more causes than one combine to produce the result. These causes can be classified under four general headings:

Brush jumping.
Commutator ring-fire.
Current surges.
Bad commutation.

Brush jumping long has been known to be a cause of railway-motor flashovers. Hellmund[1] in 1935, made a rather thorough study of the theoretical factors involved. Brush jumping was a common cause of flashovers on the older type of streetcar and interurban axle-hung 600-volt railway motors that used series-type armature windings and only two brush arms. Sudden rail impacts often caused all the brushes on one of the two brush arms to leave the commutator thus drawing an arc between brush and commutator such as is one of the characteristic conditions preceding a flashover. The prescribed remedy usually has been to use a high brush pressure to keep the brushes on the commutator under severe conditions. Brush pressures as high as 9 pounds per square inch are used on modern railway-motor brushholders. Diesel-electric road-locomotive motors have multiple-wound armatures and require as many brush arms as poles (usually four or six); therefore, track impacts do not have the same tendency to cause all brushes of one polarity to leave the commutator as on the older 2-brush-arm motors. That brush jumping is one of the causes of diesel-electric motor flashovers, however, is evidenced by the many reports and observations of repeated flashing on certain sections of rough track, or at crossovers.

The condition where brushes have worn to the point where there is no longer sufficient finger pressure on them, also should come under this general heading. Such brushes can leave the commutator surface and cause flashovers even on the smoothest kind of track. Rough or eccentric commutators will cause brush jumping, especially at high speeds if the commutators have high or low spots around the circumference.

Running a motor above its maximum allowable speed can put strains on the commutator bar assembly that are likely to produce a rough commutator and resultant brush jumping. The maximum allowable speed of the locomotive with a certain gear ratio always is stated definitely by the manufacturer. If this is 65 mph, for example, any considerable amount of running above that speed is likely to initiate trouble. A locomotive that has a 65-mph maximum speed is not "a 65-mph locomotive." It should be applied in service where there is a margin between the usual top operating speed and the stated maximum speed.

The following operating causes should be classified under the general head of brush jumping:

Eccentric commutator.
High bars.
Flat spots on commutator.
Short brushes.
Broken brushes.
Running over rough track or railroad crossings at high speed.
Exceeding maximum motor speed.
Rough or beaded commutator due to previous flashover.

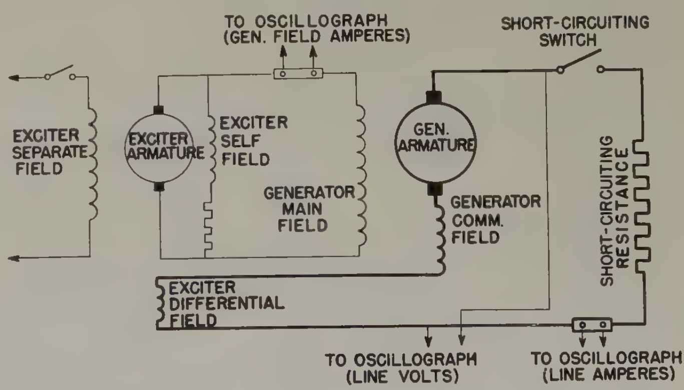


Fig. 6. Schematic diagram of test circuit used for producing generator flashovers

Commutator ring-fire as a cause of flashover includes a number of contributing causes. Even new motors with commutators well-polished and almost perfectly concentric will develop ring-fire at operating voltages if they have small metallic particles such as copper dust or copper slivers from the undercutting operations left in the slots between bars. Metallic particles such as small steel cuttings are sometimes blown onto the motor commutators with the ventilating air. These are almost certain to produce ring-fire followed by a flashover. Conducting material, such as carbon dust, brake-shoe dust, or road dust mixed with oil and water, are probably the most common causes of ring-fire due to their general prevalence on railway-motor commutators. Conducting material on the commutator Vee-ring extension is conducive to extending ring-fire from brushholder to brushholder.

That wheel slipping at high speed is one of the causes of motor flashovers is indicated by the increase of the number of flashovers in the autumn on certain lines where wet leaves are likely to be on the track. Certain sections of track known to be slippery for other causes have been reported by trainmen as the locations of repeated flashovers. One such location was found to be where creosoted logs were being dragged over the track.

The following reported causes of flashovers should be classified under the general heading of ring-fire:

Metallic particles in commutator slots.

Carbon dust, dirt, oil, or water on commutator.

Conducting material on Vee-ring extension.

Conducting material on commutator risers.

String band recently painted and placed in operation before drying.

Wheel slipping at high speed.

Excessive voltage from generator.

Excessive voltage due to dynamic braking at too high speed.

Defective field shunts causing too much shunting of field current.

The subject of *current surges* as a cause has been emphasized in the description of test-floor-produced flashovers. Anything that will cause large and sudden changes in the amperes of the motor circuit can cause arcing at the brushes which may grow into a general flashover. This would include the following reported causes under current surges:

Loose brush shunts which may cause short circuits to ground.

Brush shunts touching commutator risers.

Too sudden application of dynamic braking at high speed.

Improper operation of automatic transition relays or contactors.

Short circuits or grounds in wiring or windings of motor.

Short circuits or grounds in locomotive wiring external to motors.

Main contactors opening and closing under heavy load.

Loose connections in main circuits.

Rapid change of generator voltage due to loose connections in generator field circuit.

Rapid surging of load regulator.

Rapid surging of engine governor.

Reversal of power while locomotive is moving in opposite direction.

The degree of sparking at the brushes can be observed easily if the trailing edge of the brushes can be seen. D-c machines that spark even to a small degree under steady-state running, usually are criticized. Actually, continuous sparking may be quite severe without in itself producing a flashover. The ultimate result of continued bad commutation is to impair the surface of the commutator, so that one or more of the other causes will produce a flashover more easily. Bad commutation, then, must be listed as one of the general causes of flashovers. The following may be listed as contributing to bad commutation:

Brushes not seated.

Lack of brushholder finger pressure.

Brushes worn beyond limit of wear.

Brushes stuck in brushholders.

Improper grade of brush or mixed grades on same commutator.

"Raw" commutator surface.

Standstill burns on commutator.

Brushholder clearance from commutator not correct.

Brushholder moved from correct neutral setting.

Running locomotive over maximum speed (overspeeding motors).

Wheel slippage (overspeeding motors).

Excessive dynamic-braking current and/or voltage.

Field shunts defective so as to cause motors to run in too weak field.

OPERATING CAUSES OF GENERATOR FLASHOVERS

Fundamentally a d-c generator is subject to the same causes of flashover as a d-c motor. On a diesel-electric locomotive, however, the generator does not encounter the same conditions as the motors. The generator does not receive the sharp rail impacts like the motor, is not subject to extreme overspeeding, and always has the strongest field when its voltage is highest. It may have similar conditions of metallic particles, dirt, oil, or water on the commutator, rough or eccentric commutator, or poor commutation similar to the causes listed for the motors. Unlike the motors, the generator may have overvoltage due to improper main-field setting accompanied by overspeeding due to improper engine-governor setting. Standstill burns and resulting flat spots on the commutator may be caused during engine starting with a low battery. Voltage and current surges may be initiated in the generator by surging of the load regulator or engine governor. One item of greater importance on generators than on motors is the maintenance of the correct spacing of brushholders from the commutator. Motors, requiring rotation in either direction, use radial brushes, and the reason for keeping the brushholders at the correct distance is to prevent actual rubbing of the commutator if too close, or brush chattering if too far. Since the generator always rotates in one direction, advantage is taken of this fact for using inclined brushes because they give more uniform contact with

the commutator. If the brushholder is not at its correct distance from the commutator, the inclined brush is moved circumferentially around the commutator, thus moving the brush off its correct neutral setting.

A relisting of flashover causes for the generator similar to those for the motor is not necessary since an examination of the motor list will show readily which ones do not apply to generators. This list, however, does not contain the most important cause of generator flashover. The most prolific cause of this by far is a large and sudden current surge caused by motor flashover. This is confirmed by the fact that few cases of generator flashing are reported where motors have not shown effects of flashing also. When a motor flashover occurs, the result is similar to a near short circuit on the generator. If the current value reached is high enough, the generator will flash over. As soon as this occurs, the voltage at the generator terminals becomes low and the motor flashover quickly dies out. All this occurs in a small fraction of a second. This is the reason many reports read, "Motors lightly flashed, generator heavily flashed." The generator flash will continue and cause severe damage unless means are employed to reduce its voltage and the power input from the engine. Not every motor flashover will cause a generator flashover, but if the sudden surge of current is high enough, it will. It is the writer's belief, based on the examination of many reports, that fully 90 per cent of generator flashovers are initiated by motor flashovers.

CONTROL FACTORS AFFECTING MOTOR AND GENERATOR FLASHING

CONTROL DESIGN factors affecting flashing may be either for prevention or for minimizing effects. In the original layout of a control arrangement, attention should be given first to those factors which will tend to prevent motor and generator flashovers. Principal among these are provisions for preventing large and sudden current surges and the selection of motor connections that will allow the generator to operate over its most favorable volt-ampere range. Accepting the fact that flashovers are not preventable completely, the control also should provide means of removing generator voltage and power quickly in case of either a motor or generator flashover.

Consider first the preventive factors. Current surges are associated mainly with the switching operations that are necessary for motor field shunting, transition from series to parallel motor connections, or changing from motoring to dynamic braking. Current increases due to operations of regular field shunting steps ordinarily are not large enough or sudden enough to cause a flashover. Tests on motors have shown that even when running at maximum speed and maximum field shunting, they can be thrown alternately into full field and back into maximum shunting without serious arcing at the brushes. It is usually when some incorrect operation of contactors takes place that flashovers occur in connection with motor field shunting control. A considerable number of flashovers has been reported as a result of improper handling of the transition lever in manual transition. It is undoubtedly for this human-element reason that automatic transition largely has supplanted manual transition. Flashovers also may occur if automatic transition relays and contactors operate improperly. This simply means that these relays and contactors must be designed and built so they will act unerringly.

Sudden and excessive dynamic braking current can cause every motor on a locomotive to flash over. In motoring operations, the motor current is low when the speed is high. When dynamic braking is applied at high speed, the motor becomes a separately excited generator, and only requires sufficient excitation to make it supply both excessive current and voltage. If these excessive values are obtained suddenly, the danger of flashover is greater. The application of dynamic braking never can be taken entirely out of the hands of the engineman, but the control limitation of current and voltage must be definite and positive.

The arrangement of motor connections to the generator and whether or not to use more than one motor connection combination depends on the number of motors used and the amount of power per generator unit. The possible arrangements for a certain locomotive should be studied and compared from the viewpoint of simplicity of control arrangement and the minimizing of conditions which tend toward producing flashovers of motors or generators.

Consider next the control factors that will minimize the effects of flashovers. Much has been done during the last few years to make the control more effective in removing voltage and power from the generator when a flashover does occur. Test-floor-produced flashovers have shown very definitely that the duration of a flashover has a great deal to do with its destructiveness. An uncontrolled generator flashover on a locomotive results in a large amount of power from the engine being dissipated in the arc. This continued for even 1/2 second can be very destructive.

An improved type of ground relay has been developed which is positive not only in detecting a ground anywhere on the power circuit, but also will detect a flashover on either generator or motor as soon as the arc is grounded. Positive action of the relay is obtained by means of a "biased" alternating current supplied to the ground relay coil circuit through a small transformer.

In addition to the "biased" ground relay protection, an impulse relay has been developed that operates on the rate of rise of the main generator load current. Since a generator flashover is usually preceded by a very sudden rise of line current, this rise is made to operate the relay. The relay is used to operate the generator main field contactor to insert a relatively high resistance in the main field circuit. This has proved very effective in reducing the duration of a generator flashover.

Fig. 7 is a tracing of an oscillogram of a test-floor-produced flashover on a generator that shows the effect of using this relay. This flashover was produced by short-circuiting the generator at full speed and high voltage in a manner similar to that described in connection with the oscillogram of Fig. 5. The same generator was used in each case. In this case, the short-circuiting resistance was much less than in Fig. 5, being only 0.019 ohm as compared with 0.106 for Fig. 5. The flashover started approximately 1/60 second

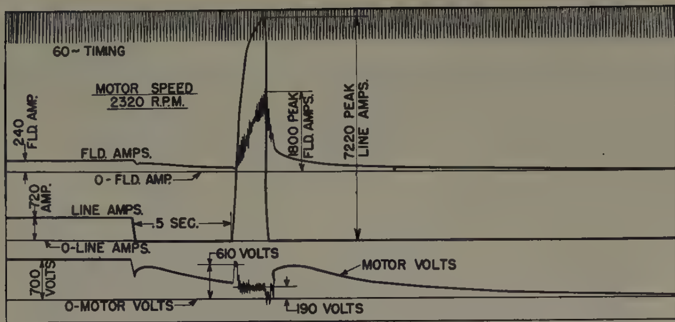


Fig. 7. Tracing of oscillogram of generator flashover produced by short circuit and limited by impulse relay

after the short-circuiting switch was closed, as shown by the sudden drop in line amperes and armature volts. Although not shown in the oscillogram, the impulse relay operated in less than 1/60 second to insert resistance in the generator field. The presence of this relatively high resistance in the main field circuit limited the peak of induced field current to a much lower value than shown in the unprotected flashover of Fig. 5. Also, the field amperes reached a low enough value to cause the arc to go out in approximately 4 cycles of the 60-cycle timing wave as compared to 22 cycles in Fig. 5. This limitation of the peak generator field current limits the flashover damage, so that repeated flashovers can be produced without damage to the extent that would require removal from service.

WHAT CAN BE DONE ABOUT FLASHING?

It will probably continue to be an unsettled question as to whether those who manufacture diesel-electric locomotives and their equipment or those who maintain and operate them can do the most to eliminate flashovers. The view one takes of this usually depends on which side of the fence he is. The truth is that both can do more than has been done in the past.

Manufacturers can utilize all of the known factors that will prevent flashing in the fundamental motor, generator, and control designs. They can incorporate also in these designs features which will minimize the effect of flashovers if they do occur. They can arrange the apparatus in the locomotive so that it is accessible for cleaning and adjustment and is unlikely to become dirty and out of adjustment in short periods of time. They can arrange the ventilation-air intakes so that clean air always is supplied to rotating equipment. They can manufacture uniform products so that each machine is as good as any other of the same design. They can supply the operator with thorough instructions as to apparatus construction and the maintenance procedures required. These are admittedly general fundamental statements, but are the goals that should be kept in mind by everyone engaged in the manufacture of diesel-electric locomotives or their electric equipment.

The operators of these locomotives can reduce the number of flashovers first of all by keeping them cleaner. This is a simple and general statement too, but motors, generators, and control apparatus of the power and voltage required on modern road locomotives always will be more subject to flashovers if wet, oily, and dirty. The extreme contrast between the state of cleanliness of similar equipment in stationary powerhouses and that on the average diesel-electric locomotive is a distinct shock to the layman who sees the comparison for the first time. Operators can instruct their operating and maintenance personnel more thoroughly in the causes of flashovers and maintenance to prevent them. They can assign locomotives to service such that there is a margin between the usual maximum operating speed and the stated locomotive maximum speed. They can make needed repairs promptly.

It is unlikely that flashovers on diesel-electric locomotives can be eliminated entirely. Their frequency can be reduced and the amount of resulting damage minimized by a better understanding and use of the causes and remedies. It is hoped that the information given in this article will contribute toward that desired result.

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European Television Hookup

One of the biggest experiments in international television began June 6, 1954, when eight European countries joined together in a 4-week continental television hookup. The experiment, called "Eurovision," will link Britain, France, Germany, Italy, Denmark, Holland, Belgium, and Switzerland. A total of 18 programs will be exchanged involving 44 transmitters.

A major technical problem has been the difference in picture standards, since Britain's picture is divided into 405 lines, France's into 819, and that of the other countries into 625. Converters are being placed in Breda, Holland; Paris, France; and Dover, England, to make the alterations necessary for the country involved. For example, for converting from French to British standards, an 819-line picture is displayed on a specially coated cathode-ray tube and the scanning lines are broadened to eliminate the line structure. The picture then is retelevised by a camera placed in front of it, working on the 405-line system.

Application of Shunt Capacitors to Network Systems

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A low power factor has been caused in many systems during the summer months which is becoming an increasing problem in voltage regulation of distribution systems and networks. The installation of capacitors on the low-voltage side of networks is one way to increase materially the available capacity of network transformers. This and other applications are discussed together with a description of new submersible corrosion-resistant capacitors which have been designed to be suitable for application in transformer vaults.

THE LOADS connected to secondary network systems in past years have been predominantly for illumination and the networks have operated at power factors of 90 per cent or better. This condition is no longer true. The accumulation of small motored appliances, water coolers, business machines, and other electric conveniences, plus the recent heavy addition of room coolers and air-conditioning equipment, has reduced network power factors to as low as 80 per cent during peak load periods. This decreased power factor together with the rapid growth of load already has exhausted the reserve capacity of many systems, and prompt expansion is necessary. Low power factors naturally suggest the use of capacitors and many analyses have shown that modern capacitors can recover economically much of the system capacity that has been lost through low power factor. In a number of cases this has been put to trial and confirmed by the performance of actual capacitor installations. As a result there has arisen a new and important field of application for power capacitors.

There are many capacitors in use in underground vaults and on secondary networks. For the most part, however, these have been adaptations of industrial or overhead distribution equipment or else specially designed for a particular service condition. Although these have served their purpose very well, there has been an increasing demand for secondary network capacitor equipment that has been designed especially for this type of service. It is therefore the purpose of this article to discuss the requirements of secondary network capacitors and to describe equipment that recently has been made available. While this has to do mostly with practical operation, one of the requirements is the availability of suitable ratings of equipment. To this extent, some factors bearing on the economics and the choice of ratings also are considered.

EFFECT OF CAPACITORS ON THE NETWORK

THE fundamental result of connecting a capacitor to a low power factor circuit is, of course, the reduction or elimination of the lagging reactive component of current. The power factor is improved to an extent depending on the amount of capacitors connected. Among other things, this results in reduced heating of conductors and associated apparatus or in increased ability to carry paying kilowatt load without overheating. It also results in less voltage drop and increases the ability to deliver power to the load at the proper voltage. There are also many contingent benefits, of which decreased losses in the system is not the least.

These effects assume various degrees of importance in different applications. For example, shunt capacitors are applied most frequently to primary distribution circuits on the basis of voltage improvement. Such benefits as improved thermal capacity and reduced system losses, while desirable, are usually incidental to the principal object of improving voltage regulation. In the case of overloaded secondary networks, the basis for capacitor application is the gain in usable network capacity. The primary object is to reduce the thermal burden on cables, transformer, and protectors. Special cases will occur of course where voltage improvement is of major benefit, but on the whole the object of installing capacitors in networks is to increase the usable capacity of the system from a thermal standpoint.

To illustrate how capacitors relieve the load on a secondary network it is of interest to observe the effect of an actual installation. Fig. 1 shows a 24-hour load chart for a network having an installed capacity of 52,000 kva and to which is connected a large air-conditioning load. During the peak hours the system is shown to be loaded to 62 per cent of its installed capacity. Considering the diversity of loads that must exist among the individual network units, it is obvious that reserve capacity for emergency operation must be nonexistent at many vaults. The power factor is of particular interest. During peak load periods it hovers between 82 or 83 per cent and at light loads it drops to 69 per cent.

Fig. 2 shows what happens when capacitors are connected. Here, 4,500 reactive kva (kvar) or 8.6 per cent of the installed network kilovolt-amperes has improved the power factor to 89 per cent at peak load and 98 per cent in the early morning hours. The peak demand has been reduced to 58 per cent of installed capacity. Fig. 3, in which

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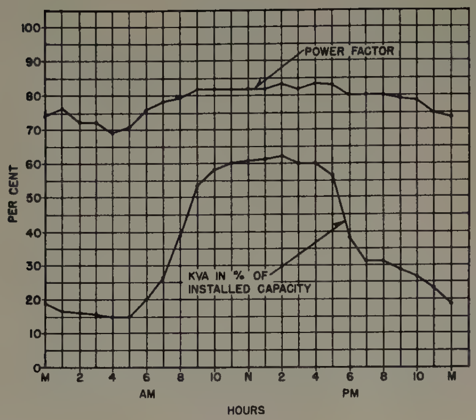


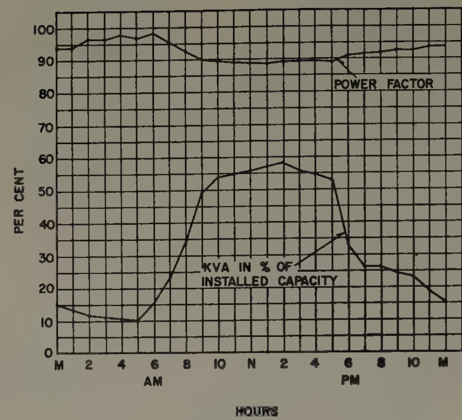
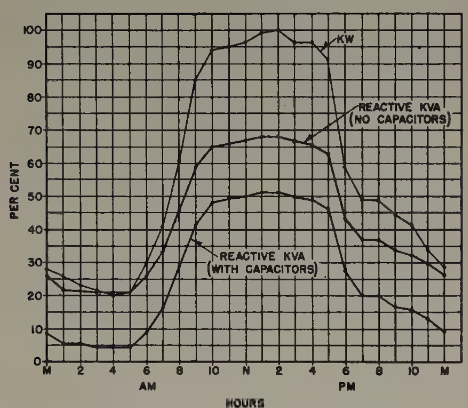


Fig. 1 (left). A 24-hour load chart for a secondary network without capacitors. Fig. 2 (right). A 24-hour load chart for a secondary network after capacitors have been installed



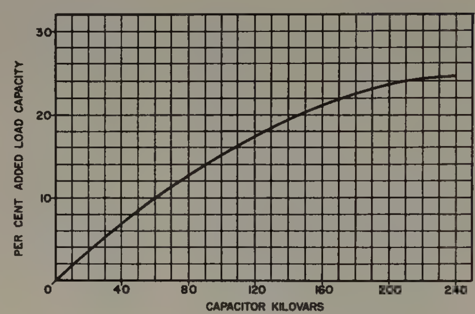


Fig. 3 (left). Secondary network load chart with the power and reactive components separated to show the effect of capacitors. Fig. 4 (right). Gain in usable capacity obtained with capacitors for a 500-kva transformer supplying an 80-per-cent power factor load

the power and reactive components have been separated, shows the effect of the capacitors more clearly. It is obvious that still more capacitors can be used on this network with beneficial results.

There is some concern with regard to the effect of leading power factor during light load periods. This has not as yet been analyzed fully, but some excess of capacitor kilovars does not appear to be hazardous. Regulation of the network voltage should control any trend toward excess voltage due to leading current. Experience has indicated that fixed capacitor kilovars amounting to some 15 per cent of the installed network kilovolt-amperes can be applied without experiencing difficulties.

SELECTION OF CAPACITOR RATINGS

The preceding charts have shown the effect of capacitors on the network as a whole. In the application it seems more appropriate to consider individual capacitor installations as associated with particular transformers. Thus the capacitor can be taken as a component of the network unit, the size of the capacitor being determined by the size of the transformer it is to serve. Fig. 4 shows the gain in usable kilovolt-amperes obtainable with various amounts of capacitor kilovars connected to a 500-kva transformer. This is based on a load power factor of 80 per cent. It is shown that a maximum gain of 26 per cent could be obtained with 240 kvar which would correct to 100-per-cent power factor. Such an application, however, undoubtedly would lead to difficulties at light loads unless the capacitor were switched automatically. In general, automatic switching of secondary network capacitors does not appear attractive.

A practical solution is to choose a capacitor of such size that it can be connected permanently and yet not supply an appreciable amount of overcorrection during light load. A capacitor that will improve the peak load power factor to about 90 per cent usually is found to meet this requirement. Under the conditions assumed for Fig. 4 a suitable capacitor size is found to be 80 kvar. The gain in usable kva with this amount of correction is 12 to 13 per cent which is a sizable improvement. In specific cases, careful analysis may show that larger capacitors are permissible, and a correspondingly greater gain obtained.

A load power factor of 80 per cent was assumed for the purpose of illustration in Fig. 4 because this appears to be a typical situation. It is of interest, however, to consider the gain obtainable at other load power factors. This is shown by the lower curve in Fig. 5, this example also being for an 80-kvar capacitor and a 500-kva network unit. The per cent of usable load capacity gained ranges from 15 per cent at a 75-per-cent power factor to 11 per cent at 85.

Small space requirements and ease of installation are important influences in the choice of capacitors as a means of gaining network capacity, but economic considerations are the major factor. Capacitors are attractive only if the cost compares favorably with the cost of adding more or larger transformers and cable. The upper curve of Fig. 5 shows this cost. With an 80-per-cent power factor load, network capacity can be recovered at a cost of less than $40 per kilovolt-ampere, which is about half the initial investment in the network. This is based on an installed cost of $20 per kilovar for the secondary capacitor.

In the examples that have been discussed a 500-kva transformer in combination with 80 kvar of capacitor has been used for illustration. It has been pointed out that this is a good practical combination from which is obtained

a 12- to 13-per-cent gain in usable capacity and which should avoid over-correction difficulties at light load. This same ratio holds true for other transformer ratings and furnishes a convenient guide for network capacitor applications. Table I shows the appropriate capacitors for other

Table I. Increased Load Capacity Obtainable With Capacitors Connected to Network Transformer With 65 Per Cent Usable Transformer Kilovolt-Amperes

Transformer Rating, Kva	Capacitor Rating, Kvar	Kilowatts of Usable Capacity: Without Capacitor		Kilowatts of Usable Capacity: With Capacitor	
		90% PF	80% PF	80% PF	% Gain
300	40	176	156	173	10.9
500	80	293	260	293	12.8
750	120	439	390	440	12.8
1,000	160	585	520	587	12.8

transformer ratings, together with the gain in usable capacity. The net result of such capacitor-transformer combinations is to bring the circuit power factor back to 90 per cent and thus recover the network capacity that has been lost by decreasing power factors.

THE SECONDARY CAPACITOR UNIT

Recent developments in the manufacture of low-voltage capacitors have been an important factor in the economics of network applications. The principal problem in the manufacture of these units is the control of flaws in the very thin insulation. Some of these stem from the paper used as the dielectric, and others are incurred in the course of manufacture. On the other hand, many critical factors that must be observed in the design of high-voltage units because of high-voltage gradients are diminished greatly in importance. An intensive study of the source of flaws has revealed ways of controlling them to the extent that the practical manufacture of capacitors of larger kilovar rating now is possible.

The development studies leading to these new ratings were started more than 6 years ago and capacitors rated 15 kvar 230 volts now have been in production and use for over 2 years. Thus the design has been tested by field service in addition to the many engineering tests preceding commercial production. In comparison to the previous $7^1/_2$-kvar 230-volt unit which was the standard, the new unit provides double the kilovars with a volume increase of only 20 per cent. A space reduction of 40 per cent thereby is obtained in capacitor equipments using these new units.

As has been pointed out previously, many capacitors which were designed for industrial use and for overhead secondaries have been used in secondary network installations with satisfactory results, and a large number of these new 15-kvar 230-volt capacitors are already in use at network voltages. However, conditions now have warranted the production of a capacitor in which the special requirements of underground network service are given primary consideration. A secondary network capacitor equipment therefore has been made available. This new network capacitor unit is rated $13^1/_3$ kvar, 216 volts. The insulation and construction is basically the same as the 230-volt distribution capacitor but special attention has been given to high ambient temperatures, corrosion resistance, high fault current protection, and submersible operation.

TEMPERATURE CONSIDERATIONS

Capacitor units generally are designed for ambient temperatures of 40 to 50 C depending on the arrangement, spacing, and ventilation. In the confined space of network vaults, however, a permissible temperature of at least 55 C often is necessary. This is accomplished in the network capacitor by establishing a $13^1/_3$-kvar rating for the 15-kvar case assembly. This reduction in kilovars plus the design of the unit for low thermal gradients permits operation in 55 C air temperature.

In the application of these capacitors consideration must be given to conditions of spacing, arrangement, air movement, and radiant heat. A spacing of 2 inches between adjacent units should be maintained for adequate air passage, and no more than one tier of units should be arranged in a group if they are located where an air temperature of 55 C is attained. In many cases, however, the only available space is above the network transformer where space limitations also indicate single tier arrangements.

CORROSION RESISTANCE

One of the most effective and economical methods that has been developed for the protection of steel against rust and corrosion is a sprayed coating of zinc covered by a suitable organic finish. By using the spraying method, molten zinc can be applied to the steel surface in a layer of 8 mils or more in thickness, and many times the thickness attainable by hot dipping. Moreover, the grainy porous surface of the sprayed zinc provides an ideal base for paint which causes the sacrifice of zinc to be retarded greatly.

The steel case of the secondary network capacitor therefore is protected by a heavy sprayed coat of zinc, 8 mils or more in thickness, and which in turn is covered and permeated by an organic finish. The life expectancy of this protection when immersed in either acid-contaminated fresh water or in sea water has been found to be 10 years or more. Under practical conditions and with reasonable maintenance this expectancy will be greatly extended. In dry vaults, or where the capacitor is subjected to infrequent submersion, an over 25-year maintenance-free life is expected.

FAULT PROTECTION

The hazard of explosion is always a factor of major concern with network vault equipment. The secondary

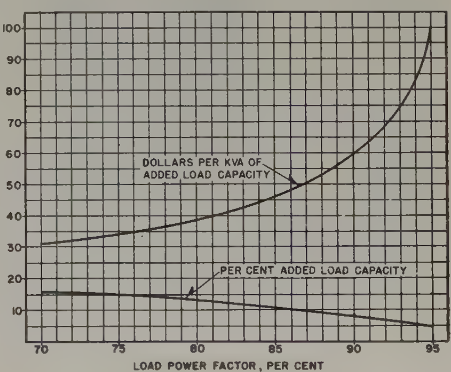


Fig. 5. Gain in load capacity and cost per kva gained for an 80-kvar capacitor applied to a 500-kva network unit

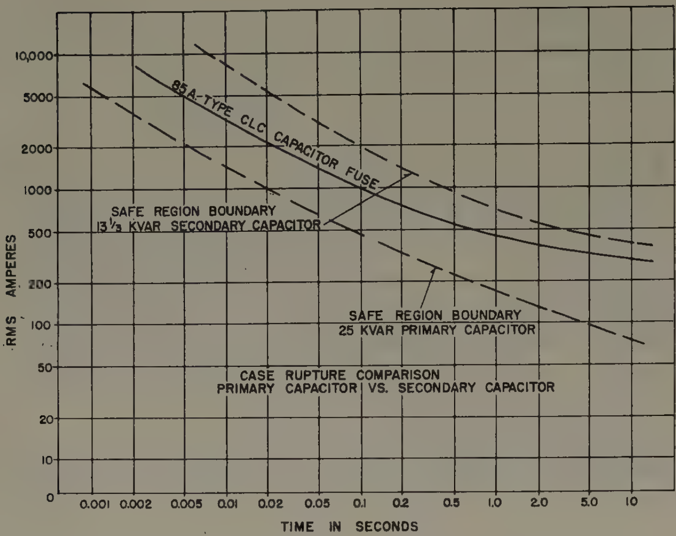


Fig. 6. Time of opening for the current-limiting capacitor fuse with case rupture characteristics of primary and secondary capacitors shown for comparison

capacitor is impregnated and filled with Askeral, as has long been standard practice for all power capacitors in this country. The hazard of primary explosion due to case rupture, and also the hazard of service shutdown, depends on the protective device furnished with the capacitor.

A new terminal-mounted current-limiting-type fuse has been developed for use with the secondary network capacitor. The current-limiting characteristic renders the fuse operation virtually independent of the fault-current capacity of the system. In addition the time of opening has been co-ordinated with the time–current curve of case rupture exhibited by the $13^1/_3$-kvar capacitor. These characteristics are shown by the curves of Fig. 6.

It is well known that primary distribution capacitors must be protected individually with fuses of 50-ampere capacity or less if freedom from case rupture is to be insured. However, this is not necessarily true for secondary capacitors for reasons which are easy to see. The rupture of a capacitor case following failure depends on the amount and rate at which energy is liberated in the fault. The rupture is due to gas pressure caused by chemical breakdown and volatilization of the liquid and cellulosic material in contact with the arc in the insulation fault. The arc or fault resistance is of course a variable quantity and depends on a number of conditions. In the secondary capacitor the thin spacing of the foil plates, along with the proportionately greater amount of metal available to carry current into the point of fault, results in a much lower fault resistance than for the higher voltage primary capacitors. Therefore, the same fault current flowing into the secondary unit represents much less energy than when it flows into a faulted primary distribution capacitor.

Fig. 7. The $13^1/_3$-kvar 216-volt secondary capacitor unit with its fuse and terminal sleeves

Fig. 6 shows the safe region for the $13^1/_3$-kvar secondary capacitor unit that has been described, and for comparison the usually accepted safe region for conventional primary capacitors. This is expressed as a time–current relation for convenience in evaluating the protection afforded by the special current-limiting fuse, the curve for which is shown by the solid line. The secondary unit is protected from case rupture by a much larger fuse than is possible for the primary distribution capacitor.

In actual practice it has been found that the secondary capacitor fault resistance, even though it is low, almost always limits the fault current to less than 10,000 amperes at 216 volts and this can be interrupted by conventional fuses. However, the small emission of gas on blowing permits the current-limiting fuse to be sealed in a watertight sleeve without the risk of its being blown off due to the disturbance caused by interrupting high fault currents. Also, the more positive assurance provided by the current-limiting fuse makes it highly desirable. This terminal-mounted current-limiting fuse is therefore an important item contributing to the safe operation of network capacitors.

SUBMERSIBLE OPERATION

It is likely that a majority of network capacitor installations never will be submerged in water or called upon to operate while submerged. However, the large number of cases in which flooding must be expected, together with those that are submerged periodically in sea water, make this a standard service condition for which the network capacitor should be designed. The hermetically sealed construction that has been developed over the years for capacitors solves most of the problem of submerged operation. It remains to extend this sealing to terminal connections and fuses in a manner that effectively will protect them yet be convenient in installation and for servicing.

The performance of the current-limiting type of fuse permits it to be sealed in a sleeve and the terminal mounting arrangement makes it possible to waterproof and insulate both the fuse and terminal connections with the same sleeve. A heavy neoprene sleeve or boot therefore has been designed to fit snugly around a corrugation of the porcelain bushing of the capacitor, with space allowed for the fuse when mounted on the terminal stud. The inlet end of the neoprene sleeve is designed to accommodate a neoprene-jacketed cable of suitable size. Tightness of the seals at the cable entrance and around the porcelain bushing is insured by the use of hose clamps.

This construction results in a sealed capacitor unit with its individual fuse and requiring only that its cable leads be taped or waterproofed at the point of junction with other capacitor units or the secondary mains. The replacement of a fuse, or of the entire capacitor unit, is possible with a minimum of labor and no retaping of joints.

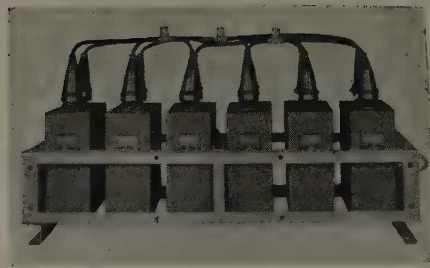


Fig. 8 (left). A 3-phase network capacitor mounted in a single-unit wall bracket. This is a useful method of individual mounting when space is limited. Fig. 9 (above). A 6-unit 80-kvar 216-volt network capacitor equipment

NETWORK CAPACITOR EQUIPMENTS

A view of the $13^1/_3$-kvar 216-volt single-phase capacitor unit along with its accessories such as the neoprene terminal sleeves, hose clamps, and current-limiting fuse is shown in Fig. 7. A special spade-type connector lug also is shown which is of advantage in connecting the capacitor to an energized circuit. When the units are grouped in banks that draw a heavy current, it is desirable to connect in the units one at a time to avoid the difficulty of energizing the complete bank without using a switch. The spade lug connector on the unfused capacitor terminal permits the wiring to be completed except for this connection, then the units can be energized individually by quickly slipping the lug around the capacitor terminal stud and tightening the contact nut.

A frequent problem in the application of secondary network capacitors is to find space in the vault. This is helped considerably by the unit construction of capacitors. The individual $13^1/_3$-kvar units may be scattered about the vault to make use of any available space if room cannot be found for a grouped assembly. Fig. 8 is a 3-phase unit in a wall bracket which is useful for individual mounting when space is limited.

In most cases it is better to group the capacitors in banks of a size suitable for the network unit requirements. This saves on installation cost and produces a neater and more compact installation. For this reason complete equipments have been developed which consist of units and accessories assembled in a rack and wired ready for connection to the mains. These are available in 3-, 6-, and 9-unit groups. The resulting ratings of 40, 80, and 120 kvar respectively, meet the usual requirements of 300-, 500-, and 750-kva transformer loads when the capacitor is considered as a component of the network unit. The 6-unit 80-kvar equipment is illustrated by Fig. 9. These capacitor equipments are designed to clear a 30-inch-diameter manhole.

CONCLUSIONS

The economic value of capacitors to secondary network systems has been established well and the increasing need for this type of equipment because of changing load patterns is being recognized by power companies. The standard capacitor equipments available in the past have not been specifically designed for the service conditions of underground network operation. To improve this situation new equipment designs now have been completed in which the problems of high-current fault protection, corrosion resistance, and submersible operation have been given particular attention. Along with these service requirements, consideration has been given to ease of installation and servicing and to flexibility in mounting arrangements. Based on analysis of rating requirements, it is anticipated that 216-volt equipments rated 40, 80, and 120 kvar will meet the application needs in a majority of cases.

Phototube for Inspection Uses

A phototube designed for production-line inspection of soft drinks, medical solutions, and similar translucent liquids has been announced by the Radio Corporation of America. The light-sensitive tube reacts to even minute transparent impurities which may be bottled inadvertently.

Equipment using this phototube is designed to react only to pulses of light caused by particles in motion. Before the bottled liquids pass the inspecting "eye" of the phototube, they are rotated swiftly, then suddenly stopped, causing the contents to swirl inside the bottles. A beam of light then is focused on each bottle as it passes the phototube. Even transparent bits of cellophane or glass will disturb the light beam sufficiently to cause the phototube to react and to trigger an electronic reject system. The phototube is highly sensitive to red and near-infrared radiant energy.

A New 115-Kv Stored-Energy-Type Capacitor Switch

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SHUNT CAPACITORS for supplying leading reactive kilovars for power-factor correction have been used on power systems for a great many years, but it is only recently that large shunt capacitor banks have been applied extensively to power systems at primary transmission voltages. Such applications have given rise to a requirement for satisfactory high-voltage switching equipment at minimum cost. Up until the present time the power system engineer has had but little choice of equipment other than the standard commercially available power circuit breakers for his capacitor switching applications. Such circuit breakers were designed fundamentally for the relatively infrequent interruption of system fault currents; were very often without special design considerations for interruption of capacitive currents; and were so costly as to restrict definitely the economic feasibility of many potential applications. Conversely, a capacitor switch should be designed to function satisfactorily when subjected to a very large number of routine switching operations, possibly several per day, without frequent maintenance periods; may be designed with relatively low fault-interrupting capacity, as fault protection is usually obtained by individual capacitor fuses and station bus differential; and should be designed for minimum cost to extend the range of economic feasibility of shunt capacitor installations at transmission voltages.

Field tests on a prototype of such a switch now have been performed successfully. These tests were conducted in a manner that has become virtually a standard in field testing of circuit breakers. The instant of contact parting was advanced through 180 electrical degrees of line voltage in 15-degree steps to insure obtaining the maximum degree of severity of line-dropping conditions. Every effort was made to determine the factor of safety designed into the breaker by changing testing parameters. It was not until the number of breaks was reduced to two, and a half normal size oil piston was used on 44 miles of line, that restrikes occurred. Fig. 2 shows that all line currents were cleared in ample time even with a reduced oil piston. Further inspection of Fig. 2, the chart showing the arc length obtained for each test, shows that as the normal design of three series breaks and full oil piston was departed from, increased arc lengths and arcing times were obtained. This indicates a reduction in the safe margin of performance.

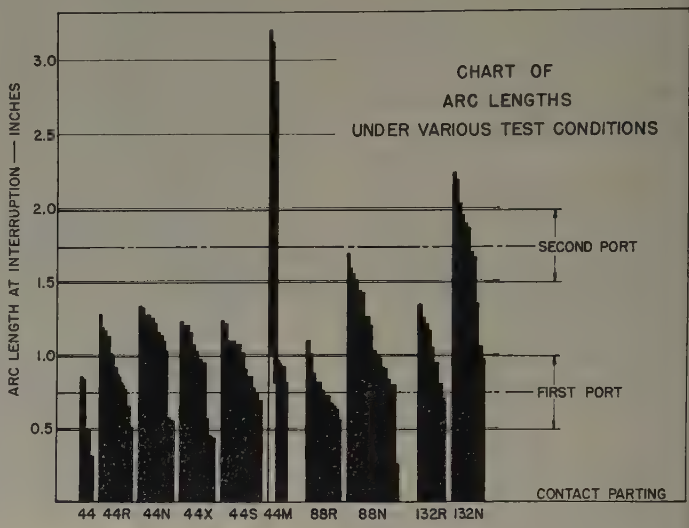

Fig. 2. Chart showing arc length obtained for each test. This chart shows three restrikes for the 44M series and no current reignition for any series

The number indicates miles of line
No letter suffix indicates full oil piston
R suffix indicates half-size oil piston
N suffix indicates smaller-size oil piston
X suffix indicates minimum oil flow
S suffix indicates two breaks, full oil piston
M suffix indicates two breaks, half-size oil piston

These tests proved that a completely restrike-free design has been accomplished through the application of the stored-energy principle of arc extinction, wherein the energy required to force the insulating fluid through the arc path is stored mechanically and is instantly available the moment the breaker is tripped. In addition, through a reduction in the continuous current rating to a value commensurate with the shunt capacitor rating, the special capacitor switch is made considerably more economical than a power circuit breaker of the same voltage class.

Fig. 1. One contact assembly, showing tulip-type finger contacts and slotted oil ports

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A New Continuous-Feed Facsimile Scanner

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G. M. STAMPS

This scanner overcomes the chief limitations of the lathe-type scanner. It is small, light, and flexible as to its optical system. A moving frame mount can be substituted for the typewriter-style roller when inflexible or bound copy is to be scanned.

FOR MANY YEARS the typical scanner used in facsimile transmission has been of what may be called the "lathe" type. In such scanners the subject copy, whose graphic content is generally to be delivered electrically to a distant recording point, is wrapped around and somehow fastened to the surface of a cylindrical drum. The copy-carrying drum then is rotated and, by means of a track and lead-screw, a photoelectric "tool" is moved axially along the rotating cylinder so as to trace a helical path over the whole copy surface. Successive turns of the helix so traced constitute the successive scanned lines of the image to be transmitted. The mechanical operation is analogous to that of a screw-cutting lathe, and the design problems and limitations are quite similar. Such a design has certain inherent operating limitations, in that (*a*) after each transmission (except for "repeats") the old subject copy must be removed from the drum and new copy wrapped around and fastened to it, and (*b*) the subject material must be in the form of thin flexible single sheets, so that the pages of a bound book or magazine are difficult to handle unless the binding is destroyed.

More recently there have been a number of attempts, by the authors' laboratories as well as by others, to design facsimile scanners that would be more versatile for various applications, and would not have the operating limitations just enumerated. Notable among these newer designs are the scanners devised by Charles J. Young and his associates of Radio Corporation of America Laboratories, Inc., in which a bright spot of light is developed upon the screen of a cathode-ray tube, swept in a straight line across the screen, and projected upon the subject copy to provide fast or side-to-side scanning. Slow, or end-to-end, scanning is obtained by continuously and progressively moving the copy itself. Thus the old drum and lead-screw are eliminated and the equipment is enabled to handle copy that is in bound form or which is longer than would be feasible for drum-mounting. Other suggestions have involved the production of a moving light spot by illuminating or observing the intersection between two transparent slits, one linear and the other helical.[1] All of these plans seemed to have implicit limitations that it would be desirable to overcome.

This article is designed to present this company's progress in developing an improved and more versatile facsimile scanner to satisfy today's requirements. It reports upon work done in the facsimile field, and implements previous reports.*

Recognizing that the Federal Communications Commission (FCC) standard of 360 scanning lines per minute not only would be what was wanted for future facsimile broadcasting but also would be adequate for short-distance wire transmission or most long-distance microwave transmission, the first commercial model, the *TX-19S*, was made for that speed. Its present form is shown in Fig. 1.

It will be noted that it was decided to use flat spiral apertures rather than the more difficult helical type proposed earlier. Also, the single-turn spiral intersecting with a linear aperture gave way to a 2-disk system. This double-disk arrangement gives a higher definition than can be had from a comparable single-spiral design. The basis of this combination is illustrated at the lower right of Fig. 1. The linear slot *S* limits the vertical size of the scanning element. The five spirals on disk *F* are five times as steep as would be a single spiral, with resultant increased definition and reduced jitter. The selection of which of the five spirals is to present the active scanning spot at any instant is determined by the second single-turn

Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, and recommended for publication by the AIEE Committee on Telegraph Systems.

John V. L. Hogan and **G. M. Stamps** are with Hogan Laboratories, Inc., New York, N. Y.

The authors wish to acknowledge the work of M. M. Schankler in the design of many of the mechanical components.

* "A Facsimile System Having Response Linear With Optical Density" by J. V. L. Hogan and F. A. Hester, a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., 1952; and "The Facsimile Transmission of News and News Photographs for Television" by J. V. L. Hogan and Dewey Frezzolini presented at the AIEE Summer General Meeting, Atlantic City, N. J., 1953. Copies may be obtained from the Hogan Laboratories, Inc.

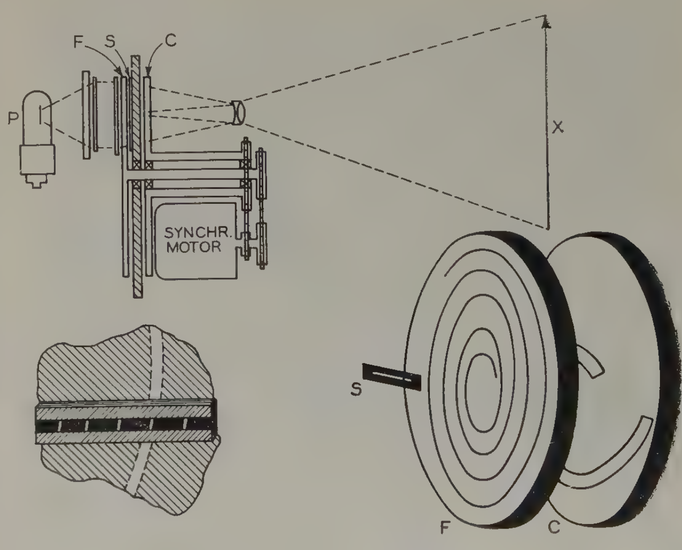

Fig. 1. The double-disk scanning system employing a slit S, a fine scan disk F, and a coarse scan disk C

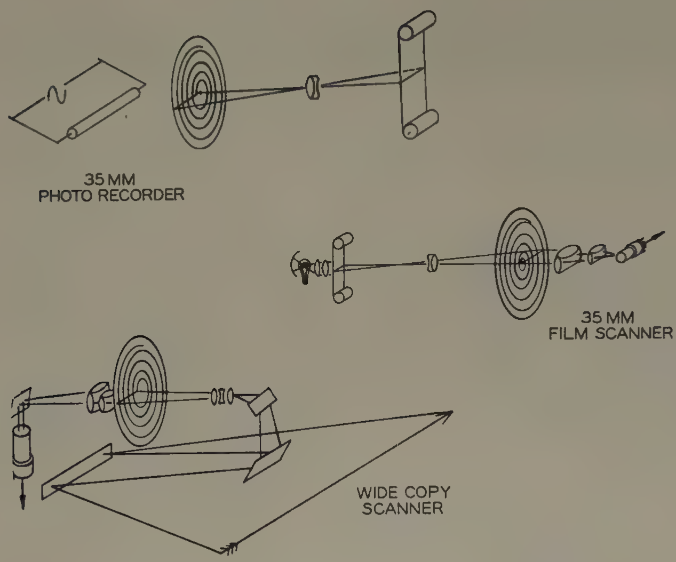

Fig. 2. Three applications employing the double-disk scanning system. Top: photo-recorder for 35-mm film using modulated light source; center: 35-mm film scanner; bottom: folded optical system used in 18-inch weather map scanner

selecting spiral *C*. The combined operation of the two spirals and the linear aperture is shown at the lower left of Fig. 1. Note that the effective aperture size is determined vertically by the slit *S* and horizontally by the narrow opening of spiral *F*. The wider aperture of spiral disk *C* does not determine definition, for disk *C* merely selects which of the five spirals on disk *F* shall be operative at any instant.

The two disks and their driving motor are shown at the upper left of Fig. 1, in one assembly. The disks are mounted on concentric shafts, and both are driven by the motor through a nonslip belting system. The motor runs at 1,800 rpm, as does the 5-turn disk *F*. The selector

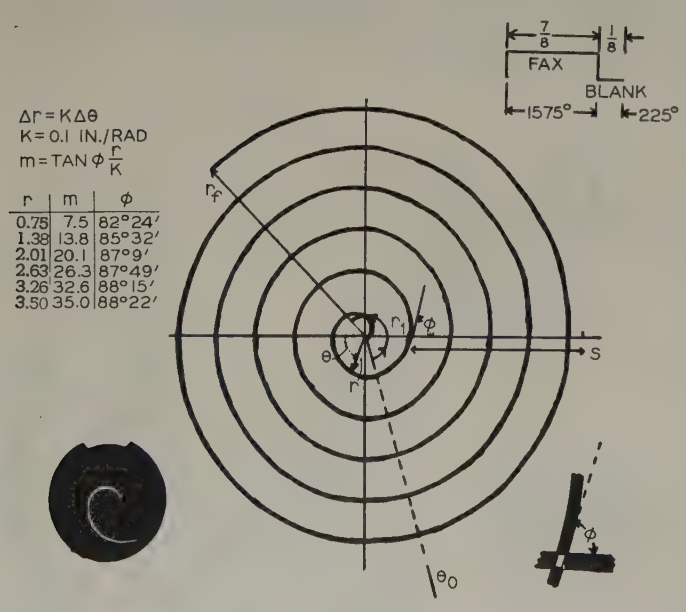

Fig. 3. The fine scan spiral showing slope values along the slit intersection region S. The intersection aperture formed is illustrated at lower right; the coarse scan disk lower left

(single-turn) disk *C* is driven at the line-scanning speed of 360 per minute. The fixed linear slit *S* lies between the two disks. This unit, comprising motor, fixed linear aperture, and two rotating spiral apertures, constitutes a basic scanning assembly that may be used with any of a large number of optical systems.

One of these optical systems is shown at the upper left of Fig. 1. Here the scanning line on the subject copy is indicated at *X*. This line of the copy is uniformly illuminated. The photocell *P* at the left looks at successive points of scanned line *X* through the action of the scanning system *F, S, C* which has been described. Scanning in the slow direction (end-to-end) is provided by uniform movement of the subject copy in its own plane, which motion is perpendicular both to the scanned line and to the plane of the illustration.

Fig. 2 indicates how the basic scanning system, comprising motor, spiral or spirals, and linear aperture, may be associated with various optical systems for use in a variety of applications. The uppermost diagram illustrates a 35-mm film photo-recorder. Incoming facsimile signals modulate the lamp at the left. Fast scanning is supplied by the spiral assembly, and the uniformly moving film at the right records photographically the received copy.

The central sketch of Fig. 2 shows how the same basic scanning unit may be used to produce facsimile signals from subject copy previously photographed or recorded on film. The film is illuminated by a light of uniform intensity (left) and the line-by-line scanning generates facsimile signals in the photocell (right). These signals may be transferred electrically to any facsimile recorder such as one for the production of full-sized paper copies of the subject matter.

Fig. 2 also shows, at the bottom, another adaptation of the basic scanning system. Here the object is to scan subject copy 18 inches in width, producing from the photocell at the left facsimile signals for transmission to a distance. The scanner unit is of the same size as used either for microfilm or for $8^1/_2$- by 11-inch copy. In order to permit the photocell to look at an 18-inch scanned line (right) without unduly increasing the over-all size of the equipment, folded optics are utilized. The 3-mirror system illustrated makes practical the use of the identical scanning unit designed for shorter scanned lines, by telescoping the required long optical system into a reasonable volume.

The heart of the system is the spiral itself. The Archimedes spiral has the property that

$$r = K\theta$$

i.e., in polar co-ordinates the radius vector r (see Fig. 3) to any point on the curve is directly proportional to the angle turned from a radial reference line, θ_0. In particular, if θ changes at a constant rate, r will increase at a constant rate

$$\frac{dr}{dt} = K\frac{d\theta}{dt}$$

It follows that the aperture formed by the intersection of an

Archimedes spiral and a slit passing through the origin (axis of rotation) moves at a linear rate when the spiral is rotated at constant rpm.

The slope of the angle of intersection, ϕ, between spiral and slit is found from the velocity ratios

$$\frac{rd\theta}{dr}=\frac{r}{K}$$

Since the intersection angle ϕ changes with r, the shape of the parallelogram scanning aperture also changes with r. In order to keep ϕ greater than 80 degrees for small values of r, K must be kept small. However, Δr, the sweep distance, must be great enough so that the width of the spiral aperture itself is not prohibitively small. Thus for high-resolution systems capable of resolving from 1,000 to 2,000 elements per sweep, either the spiral disk must be very large or the spiral must have more than one complete turn.

As illustrated in Fig. 1, a plurality of spiral turns results in a plurality of intersection apertures, requiring a second spiral having a wide single-turn spiral aperture to act as a coarse scan and to select the proper fine aperture, blanking the others.

The multiturn or fine spiral used in the *TX-19S*, see Fig. 3, has five turns and rotates at 1,800 rpm, which is a standard synchronous motor speed. Since the fine scan disk must make five revolutions to complete one sweep, the coarse scan disk turns at 1/5 of 1,800, or 360 rpm, which is the scan rate.

The output facsimile signal is illustrated in the upper right corner of Fig. 3. Following FCC broadcast facsimile standards, a 7/8 line-use ratio is used, so that 1,575° of the 5-turn spiral are used per cycle, leaving 225° with no aperture, corresponding to the 1/8 of a cycle blanking. The actual intersection angles, ϕ, for various distances from the rotation axis are tabulated at the left.

In addition to permitting the use of smaller scanning disks, the multiturn spiral has two other advantages. It greatly reduces "jitter," and it leads to an integrating effect which smooths out any defects of the spiral which may be present.

In conventional lathe-type scanners one revolution of the drum corresponds to one scanning sweep. The percentage of jitter present in the facsimile signal is the percentage departure of the drum per revolution from an exactly repetitive motion. In a 5-turn spiral scanner the percentage of jitter present in the signal is the percentage departure of the disk per five revolutions from an exactly repetitive motion. In other words, for the same rotational irregularity, this spiral scanner has one-fifth the jitter of the equivalent drum scanner. Further, since the scanning disk turns at motor speed, no reduction gearing is needed between the motor and the fine scan disk, and at 1,800 rpm a large fraction of the system loading is smooth wind friction.

The chief difficulty encountered in the course of the development of spiral scanners was the making of satisfactory spirals. There are four basic requirements which a good scanning spiral must meet.

First, the spiral must have the right shape. Any de-

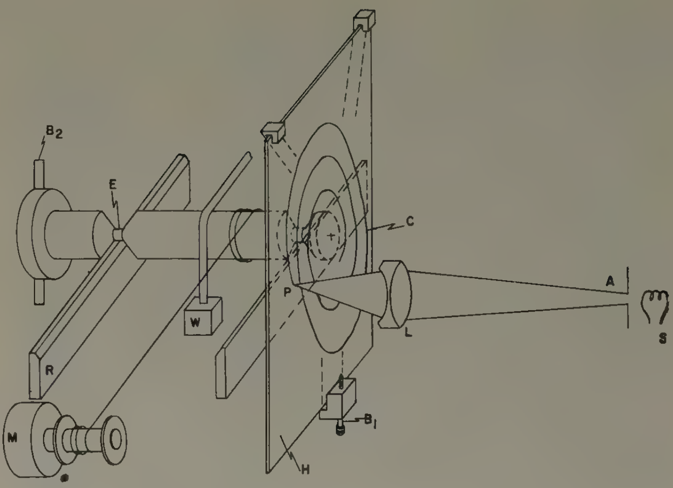

Fig. 4. The master spiral generator

parture from the correct shape produces distortions in the copy. The amount of such distortion tolerable depends on the nature of the error. A sudden "bend" or "kink" in the spiral is disastrous, whereas a slowly varying error of much larger amplitude can be neglected. This is tantamount to saying that the slope of the spiral at all points must be accurate, as well as the position.

Second, the spiral origin must be correctly centered on the axis of rotation of the disk shaft. An error of centering will cause the velocity of the sweeping aperture to vary in such a way that the spot successively leads and lags each revolution by a distance equal to the misalignment. A few thousandths of an inch of such misalignment produces detectable distortion.

Third, the aperture must be of uniform width, and errors in uniformity must become negligible when averaged out over a length of spiral corresponding to a single element. In the *TX-19S* this distance is 1.8° of arc. The width of the spiral is 0.0023 inch.

Finally, the light transmissivity of the aperture must be

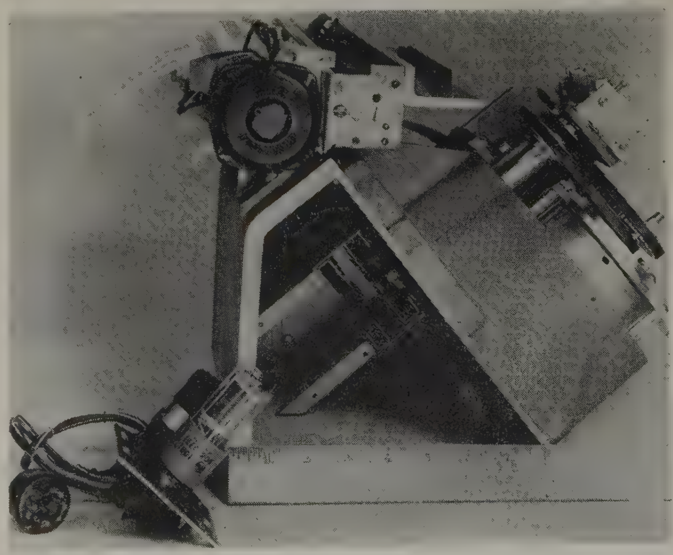

Fig. 5. Side view of the TX-19S continuous facsimile scanner with phototube mount removed. A sheet of copy to be scanned is mounted in the feed roller

constant and high (i.e., it must be clear), and the region around the aperture must be sensibly opaque.

Although several methods have been tried successfully in the making of spirals, the spirals now being used were produced photographically. A master spiral negative is made on a photographic plate, and copy positives are made for use in scanners.

The spiral generator used in making the master spiral plate is illustrated in Fig. 4. A glass Kodalith plate H is mounted at the end of a shaft E. The shaft, in turn, rests on two bevelled straight-edge steel rails. An optical system projects a small rectangle of light on the sensitive plate at point P. If the shaft rolls without slipping on the rails, then the locus of point P, originally aligned with the shaft axis, generates an Archimedes spiral on the plate. For a given spiral it is merely necessary to have the proper shaft radius.

A motor M causes the shaft to roll by winding up a dial cord line wrapped around the shaft. In order that the exposure at P shall remain constant, the speed of the motor M is continuously varied so that the spot velocity of P with respect to the recording plate remains constant. The plate is then developed in a good fine line developer, and the spiral appears as a narrow black line on the glass. A positive copy of this master on a Kodalith coated glass disk serves as the actual scanning disk.

The line of copy being scanned must be brightly and uniformly illuminated. In the *TX-19S*, see Figs. 5 and 6, illumination is provided by two tubular fluorescent lamps using a blue phosphor which makes a satisfactory match to the *S-4* response of the *931-A* photomultiplier. The scanned line of the copy is viewed between the lamps. Both lamps are operated on direct current to prevent flicker, and the polarities of the two lamps are reversed so that the cathode phenomena occur at opposite ends. With the lamps positioned as shown in Fig. 6, the copy is brightly illuminated because the phosphor surfaces are physically near, and specular reflection is avoided. The illumination of a given copy element comes from at least an inch of each lamp surface, thus averaging out lamp irregularities and striations.

In order to conserve space, the optical path is folded by a front surface mirror. A 75-mm $f/4.5$ enlarging Ektar serves as the objective lens, converging the light through the coarse scan disk to a focus in the plane of the fine scan spiral disk. The horizontal slit is between the two disks, with the slit and fine scan spiral face within 0.01 inch of each other. The apertured light is collected by two Fresnel condensing lenses. These Fresnel lenses form an image of the objective lens on the *931-A* photocathode surface so that, although the slit-spiral aperture sweeps across the image field, the light spot formed on the phototube does not move. A cylindrical lens also is used in the system to squeeze the light image on the photocathode from a circle to an ellipse to conform to the cathode shape.

The phototube circuit is shown in Fig. 7. A constant voltage is maintained between the photocathode and the first dynode to insure efficient photoelectron collection. Gain is controlled by varying the voltage between dynodes *7* and *9*.

The circuit for providing logarithmically compressed response is due to F. A. Hester, chief engineer of Hogan Laboratories, and is used in this scanner. This circuit was described by Hogan and Hester.† In this circuit dynode *9* is grounded, so that the anode potential depends on the average velocity of the electrons impinging upon it. The average velocity of electrons leaving dynode *9* is a logarithmic function of the number of electrons reaching it, which in turn is a linear function of the quantity of light flux incident on the photocathode. The voltage developed

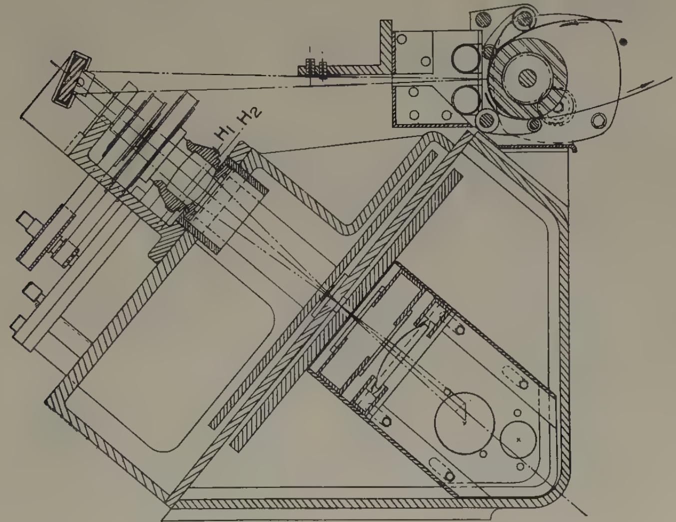

Fig. 6. Sectional view of the TX-19S

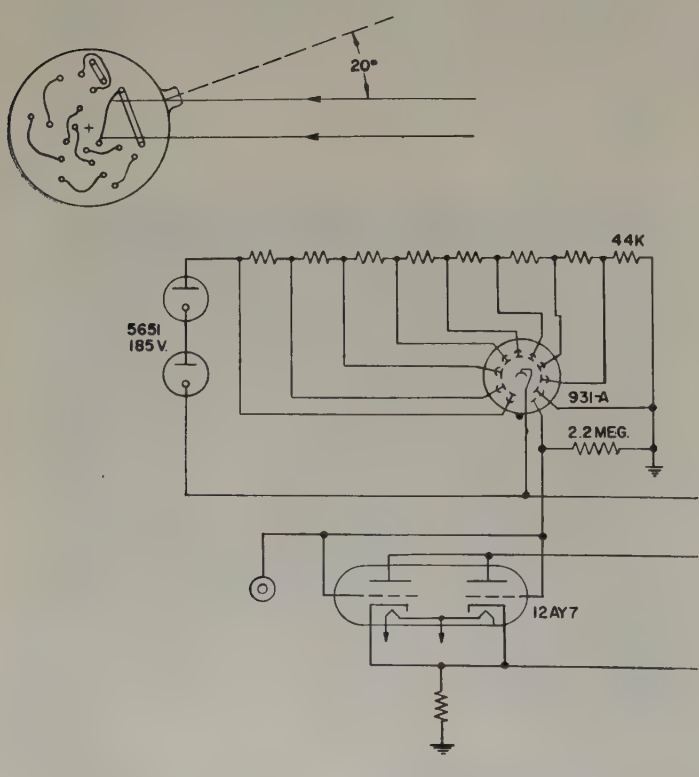

Fig. 7. Phototube circuit with logarithmic response

† See footnote p. 615.

across the 2.2-megohm load resistor is thus a logarithmic function of the incident light. Since the human eye responds logarithmically, this response matches that of the eye.

Power to drive the type *TX-19S* scanner is furnished by an 1,800-rpm salient-pole synchronous motor, see Fig. 6. Two sets of toothed rubber timing belts drive the disk shafts. The disk shafts are concentric, the inner shaft driving the fine scan disk at motor speed from a 1-to-1 pulley, and an outer sleeve shaft driving the coarse scan disk from a 5-to-1 reduction pulley.

A small separate clock-type motor drives the copy feed roller, which is essentially like that of a typewriter. This feed roller replaces the precise lead screw required in conventional drum-type scanners.

There is a loss of signal response near the ends of the sweep due primarily to the cosine fourth law of illumination characteristic of all objective lenses. In addition, some fall-off results from the oblique angle of incidence at the photocathode for light arriving from the ends of the sweep, and from the reduced efficiency of the Fresnel condensers at wide angles. The total loss from all of these causes is around 30 per cent near the ends of the sweep. In order to correct for this a compensating aperture is used. This aperture is located one-third of the way between the copy and the objective lens, and in this model consists of two rows of set screws, the two rows overlapping to form a continuum when viewed from the objective lens. There are 59 screws, the ends of which are milled flat. When a screw is extended, it penetrates into the optical path and causes a reduction in response for the section of the copy which lies in its penumbra.

By observing the response of the scanner to white copy (on an oscilloscope) and by adjusting the screws, it is easy to set the response across the scan to the linearity desired. Since the screws do not lie in a focal plane the effect of any single screw is a smoothly varying function, and since the response losses are also smoothly varying, the control afforded by the 59 screws is adequate to produce a uniform response. Once the shape of the correcting aperture has been determined in this way, the screws can be replaced by a cut sheet metal aperture. This correction is in the nature of a design adjustment and need not be changed in operation.

Fig. 8 shows an 18-inch-copy continuous scanner built for the U. S. Navy. This scanner uses a 15-turn fine spiral with an aperture of only 0.0017 inch, and resolves 2,000 elements per sweep. The optical path, folded for incorporation in a 19-inch relay rack, is shown in the bottom sketch of Fig. 2.

Besides the wide copy scanner, the spiral method has been applied successfully to the scanning of 35-mm film, as depicted in the middle sketch of Fig. 2, and also to photo-recording as shown in the top sketch. In photo-recording a modulated light source replaces the photocell and the direction of light travel is merely reversed, so that a spot of light projects onto film placed on the copy feed. Excellent photo-recordings have been made in this manner.

In conclusion, the spiral scanner described overcomes the chief limitations of lathe-type scanning. It is small, light, and quite flexible as to its optical system. There is no need to stop transmission for loading and unloading of drums, because copy can be fed into the scanner continuously. Finally, when scanning of inflexible or bound copy is required, a moving frame mount can be used in place of the typewriter-style roller. Because flood illumination rather than the spot type is employed, shielding from ambient light is not a problem. While there undoubtedly will be fields for the continued use of lathe-type scanners, it is believed that this new type of scanner is a material step forward in the art and should tend to broaden the field for application of the electric transmission and reproduction of graphic material.

Fig. 8. An 18-inch weather map scanner. Copy is scanned continuously as it feeds around typewriter-style roller

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1. **J. V. L. Hogan,** *United States Patent 2,379,438,* July 3, 1945.

NEMA Adds House Heating Section

A new section was added to the National Electrical Manufacturers Association on May 4, 1954, by the formation of the Electric House Heating Equipment Section. The scope of the section includes the following types of heating equipment principally used in houses and which use electricity as the heat source: cable units for installation as radiant heating systems; radiant panels with or without integral component motors or accessories; floor standing panels or screens and wall heaters suitable for operation at voltages in excess of 200 volts; floor furnaces, baseboard panels, and electric steam radiators.

Transient Performance of Servomechanisms

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THE UTILITY of servomechanisms depends upon the speed, stability, and accuracy of their responses. In order to achieve the best performance, it is often expedient to employ, as a correction signal in addition to the error, either the derivative or the time integral of the error, or both. The servomechanism then is said to have derivative or integral control.

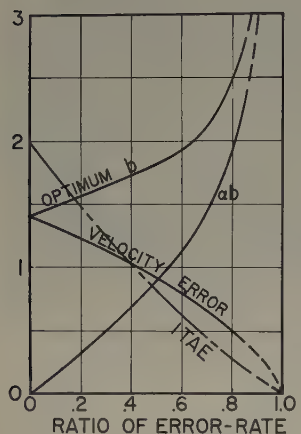

Fig. 1. Characteristics of optimum second-order servomechanisms for displacement step inputs

In a previous paper,[1] the authors developed a criterion of transient performance based upon the minimization of the integral of time-multiplied absolute-value of error (ITAE), $\int_0^\infty t|e|dt$. The factors affecting the generic qualities of speed, stability, and accuracy of the transient response are taken into account by this criterion. In the present article, the integral criterion is applied to the selection of the "optimum" transfer function coefficients of second- and third-order linear servomechanisms with derivative and integral control, and with several types of inputs.

The general normalized[1] transfer function of a linear second-order servomechanism is

$$\frac{C(s)}{R(s)}=\frac{\alpha bs+1}{s^2+bs+1} \tag{1}$$

in which α is the ratio of error-rate damping (derivative control) to total system damping. The optimum value of b, as selected by the ITAE criterion, depends upon the value of α and the form of the input $r(t)$. For input displacement step functions, the relationship between α and the optimum b is given by Fig. 1. Also shown are the corresponding values of the ITAE criterion, the optimum error-rate parameter αb, and the velocity-error constant.[2]

The responses of two second-order servomechanisms with equal total damping parameters b well may be considerably different, if they employ different error-rate damping proportions α. In general, both the speed and relative stability improve as α is increased.

The discussion above has assumed that all of the system parameters were completely at the designer's disposal. An interesting and practical problem in servo design is: given a second-order servomechanism with a certain fixed amount of output damping, how much error-rate damping should be added to produce a minimum ITAE response to a displacement step function? The solution to this problem is contained in Fig. 1, in which the velocity error curve represents the output damping coefficient $b-\alpha b$, and the αb curve indicates the amount of error-rate damping to add in order to obtain a minimum ITAE response.

The normalized transfer function of many third-order servomechanisms has the form

$$\frac{C(s)}{R(s)}=\frac{\alpha cs+1}{s^3+bs^2+cs+1} \tag{2}$$

Equation 2 describes simple third-order servomechanisms, systems with resistance-capacitance lead networks, and systems employing integral control to eliminate steady-state displacement or velocity errors. The time constants and gain parameters of these various systems, however, enter into the coefficients b, c, and α in quite a different way in each case.

As in the case of second-order systems, the optimum values of b and c depend upon the value of α and the form of the input. Fig. 2 illustrates the optimum b and c values as functions of α, for third-order systems with input displacement step functions. If the input has another form, or if the system is operating as a regulator, the optimum adjustment and corresponding responses will be different.

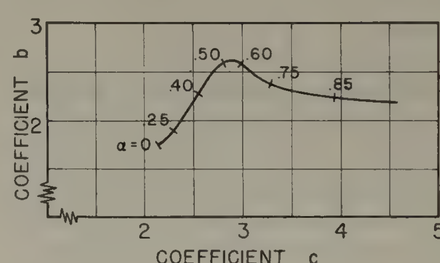

Fig. 2. The optimum parameters of third-order servomechanisms for displacement step inputs

The optimum synthesis of servomechanisms is strongly dependent upon the combination of types of damping and control which is employed, and upon the input which is most typical of the intended application. Actual designs usually represent compromises, but the formulation of desirable parameter values is a useful guide to the best compromise.

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Digest of paper 54-126, "The Transient Performance of Servomechanisms With Derivative and Integral Control," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Applications and Industry*, March 1954, pp. 10–17.

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Applying Short-Time Memory Units to Compensators

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A COMPENSATOR is a device cascaded with a control system so that the resultant output, or controlled variable, $q(t)$ is some function of the input, or command signal $v(t)$ (see Fig. 1). This article suggests methods for the design of several different compensators each of which contains a short-time memory unit as an integral part of its structure. The analysis is limited to the design of linear follower-type systems in which the controlled variable is required to approximate the command signal. Although electrical terminology is employed quite frequently herein, the theory is applicable to other physical systems.

Consider the linear control system of Fig. 1 to be represented in Laplace calculus form by the complex transfer function, $[N(s)/D(s)]$, where $N(s)$, $D(s)$ are polynomial functions of s. Let $[D_x(s)/N_x(s)]$ be the complex transfer function of the cascaded compensator as shown. It is observed that,

$$q(s)=\left[\frac{D_x(s)}{N_x(s)}\right]\times\left[\frac{N(s)}{D(s)}\right]v(s)$$

Thus for a follower, the combined operator for the over-all cascaded system should be made to approximate unity. It is assumed that $[1/N_x(s)]$ can be produced with lumped, linear passive elements, so that the approximation, $N_x(s)\cong N(s)$, holds reasonably well over the frequency range of interest. If this assumption is accepted, the primary problem becomes that of producing a physically realizable network for which the complex transfer function, $D_x(s)$, approximates the polynomial $D(s)$.

It is shown that a short-time memory unit or delay-type network, in which the output is composed of the sum of various amplified and delayed signals, possesses a complex transfer function having zeros but no poles in the finite complex plane. Use is made of this property in developing three different design procedures for representing $D_x(s)$. Comparisons are made of the frequency and phase responses of a control system when compensated by networks designed by each of these procedures.

The basic principles for one of the newly suggested devices, called the Modified Taylor's Series Compensator (or TSC), show particular promise. The over-all performance was calculated when this compensator was assumed to be cascaded with a linear second-order control system. Fig. 2 shows the amplitude and phase characteristics before and after the addition of the TSC unit. It is seen that for a short-time memory unit of fixed total length, the addition of more and more taps produces flat amplitude response with constant linear phase lag throughout an increasingly larger frequency range. Further, the magnitude of the constant linear phase lag is not altered by the addition of more taps on the delay unit. It is shown also that the magnitude of this phase lag is equal to the angular frequency of the command signal multiplied by a time interval equal to one half of that time corresponding to the total length of the delay unit. In other words, through the addition of more taps on the TSC compensator and considering a fixed total memory unit length, the compensated system amplitude response is improved with no alteration in the phase-response characteristic. Correspondingly, from another point of view, if the number of tap points is considered to be constant and the delay line length reduced successively, the magnitudes of the phase lag will be reduced in direct proportion. Also in this latter case it will be found that the reduction of delay line length will produce an increase in the flat amplitude frequency response range.

The theoretical limitations upon improvement of performance of TSC compensated systems seem almost nonexistent. However, the practical limitations are saturation of the control system and construction complexities in the compensator. The designs discussed are only three of many different "curve-fitting" techniques which might be applied to the basic theory to obtain desirable characteristics.

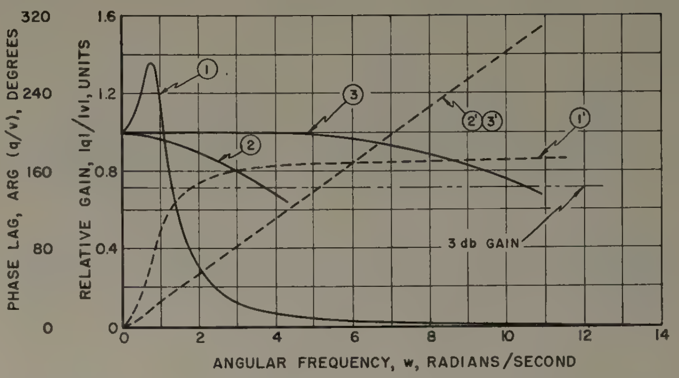

Fig. 2. Amplitude and phase responses for a TSC compensated second-order system

1,1′ = gain, phase lag for uncompensated system
2,2′ = gain, phase lag for compensated system, 3-tap TSC
3,3′ = gain, phase lag for compensated system, 5-tap TSC

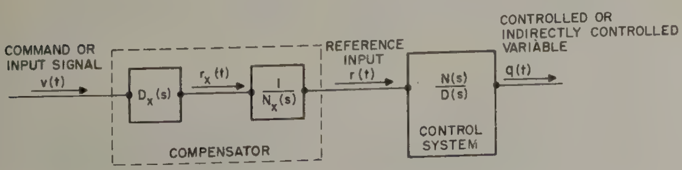

Fig. 1. General diagram of compensated system

Digest of paper 54-124, "The Application of Short-Time Memory Devices to Compensator Design," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Applications and Industry*, 1954.

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Vector Theory of Synchronous Machines

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This novel article presents Park's theory in a simple form which should be of special interest to teachers and designers of rotating machines.

THE transformation from phase quantities to direct, quadrature, and zero quantities has been of great use in the analysis of synchronous machines. This transformation has been used by Margand,[1,2] established as a theory by Park,[3,4] and its use has been amplified and generalized by Crary[5] and Concordia.[6] Park's theory is particularly suitable in the analysis of symmetrical short circuits either on the terminals or after a balanced load.[4-7*] It also is useful in the analysis of stability problems.[8]

Useful as they are, Park's equations[4] are always difficult to teach to the student of electric machinery. It is believed that a vectorial approach to the derivation of Park's equations is very useful in grasping the transformation to reference axes fixed in the rotor. Although Park[4] represents his final derived equations vectorially, and although Summers[9] has presented a vector theory, yet these vector representations do not come before the derivation of the equations. Thus even though the present article does not add a new contribution to the theory of rotating electric machinery, its value is believed to be educational in making Park's theory easier to teach.

TRANSFORMATION FROM PHASE QUANTITIES TO DIRECT, QUADRATURE, AND ZERO COMPONENTS

In Fig. 1, $\dot{r}$ is a space vector that might vary with time in any manner and has magnitude r, and a, b, c are the projections of $\dot{r}$ on the three axes A, B, C spaced 120° apart. Then

$$a = r\cos\theta \tag{1}$$

$$b = r\cos(\theta - 120°) \tag{2}$$

$$c = r\cos(\theta + 120°) \tag{3}$$

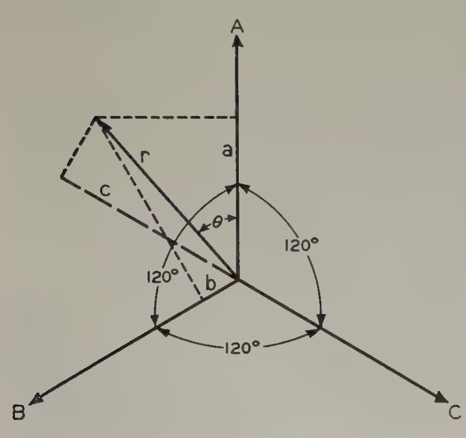

Fig. 1. Vectorial representation of phase quantities

Adding these equations gives

$$a + b + c = 0 \tag{4}$$

Conversely, it easily can be shown that if segments a, b, c are given on the three axes A, B, C spaced 120° apart such that $a+b+c=0$, then it is possible to find one and only one vector $\dot{r}$ whose projections on A, B, C are a, b, c respectively.

However, if $a+b+c \neq 0$, the procedure to be followed is similar to that followed in the theory of symmetrical components. First the residual or zero component must be extracted, thus

$$\sigma = 1/3(a+b+c) \tag{5}$$

After the extraction of the zero component from a, b, and c, the remainder consists of three numbers ($a' = a - \sigma$; $b' = b - \sigma$; $c' = c - \sigma$) whose algebraic sum is zero. And hence one vector $\dot{r}$ can be found to represent them as previously described. This vector $\dot{r}$ can be resolved further into two given perpendicular directions that may be the direct and quadrature axes of a rotating electric machine, see Fig. 2.

It also is evident from Fig. 2 that this process is reversible, i.e., given d, q, σ then d, q give $\dot{r}$, the projections of $\dot{r}$ on A, B, C being a', b', c'. Adding σ to every one of these gives a, b, c.

It should be noticed that the residual $a+b+c$ arbitrarily has been distributed equally among A, B, C for symmetry giving the zero component. However it could have been divided in any other manner giving components other than the zero component.

APPLICATION TO A 3-PHASE MACHINE

IF at any instant currents i_a, i_b, i_c flow in a 3-phase winding, and if sinusoidal distribution of turns is assumed, there would exist three space vectors of magnetomotive forces of magnitudes i_a, i_b, i_c which are displaced 120° apart. Hence the foregoing transformation can be applied, giving the direct, quadrature, and zero components of current i_d, i_q, i_0. Also if i_d, i_q, i_0 are given, i_a, i_b, i_c are obtained as the sum of projection of i_d and i_q respectively on A, B, C with the addition of i_0 to the sum of projections on each axis. These equations are given

* "Investigation on the Influence of Magnetic Saturation on Alternator Short Circuits," S. L. Mikhail. Doctor's thesis, Harvard University, Cambridge, Mass., May 1951.

A special article recommended for publication by the AIEE Committee on Basic Sciences.

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The author wishes to thank Professor Reinhold Rudenberg of Harvard University for much help and encouragement, and to give credit for the valuable notes on electric machinery by Professor C. A. Keener of the University of Illinois.

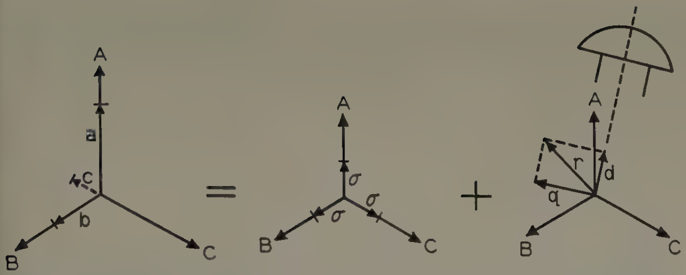

Fig. 2. Direct, quadrature, and zero components of phase quantities

by Park[4] and by Margand[2] and need not be repeated.

The same reasoning also applies to the flux linkage and the terminal voltage and similar equations can be written.

VECTORIAL DERIVATION OF PARK'S EQUATIONS

THE relation between the terminal voltage, the flux linkage, the current, and the resistance r is

$$\text{terminal voltage} = p\ (\text{flux linkage}) - r\ (\text{current}) \tag{6}$$

where $p = d/dt$. This relation can be written as a scalar equation for the zero quantities since they are not coupled to any of the other axes. Thus

$$e_0 = p\psi_0 - i_0 r \tag{7}$$

However, for the rest of the quantities, it should be written as a vectorial equation.

Thus if **d**, **q** represent unit vectors in the direct and quadrature axes respectively, there is,

$$\mathbf{e} = p\boldsymbol{\psi} - \mathbf{i}r \tag{8}$$

or

$$(\mathbf{d}e_d + \mathbf{q}e_q) = p(\mathbf{d}\psi_d + \mathbf{q}\psi_q) - r(\mathbf{d}i_d + \mathbf{q}i_q) \tag{9}$$

Where the subscript d indicates a direct-axis component while the subscript q indicates a quadrature-axis component.

The differentiations of **d** and **q** are derived in equations 15 and 16. With the help of these equations, equation 9 becomes

$$\mathbf{d}e_d + \mathbf{q}e_q = \mathbf{q}\psi_d p\theta + \mathbf{d}p\psi_d - \mathbf{d}\psi_q p\theta + \mathbf{q}p\psi_q - \mathbf{d}ri_d - \mathbf{q}ri_q \tag{10}$$

Equating the quantities in either axis, there is

$$e_d = p\psi_d - \psi_q p\theta - ri_d \tag{11}$$

and

$$e_q = p\psi_q + \psi_d p\theta - ri_q \tag{12}$$

Equations 11, 12, and 7 are Park's equations derived vectorially.

Appendix. Differentiation of a Vector in a Rotating Frame

IN Fig. 3, let the rotating frame be the rotor of a rotating electric machine, and let θ be the angle which the direct axis makes with a stationary frame of reference at any time t, then

$$\mathbf{d} = 1\epsilon^{j\theta} \tag{13}$$

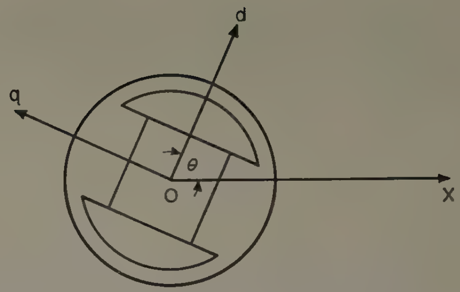

Fig. 3. Differentiation of a vector in a rotating frame: OX is a stationary axis

and

$$p\mathbf{d} = 1jp\theta\epsilon^{j\theta} \tag{14}$$

$$= \mathbf{q}p\theta \tag{15}$$

Similarly

$$p\mathbf{q} = -\mathbf{d}p\theta \tag{16}$$

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Commercial Reactor Equipment

Radiation Counter Laboratories, Inc., has announced the first commercial control equipment for a low-cost experimental neutron chain reactor. The equipment, shown above, consists of five signal channels: the counting rate channel which begins recording before the reactor becomes self-sustaining; the micromicroammeter channel which holds the power level constant; the log n or period channel to control current to the safety rods; and two safety channels

Eddy-Current Phenomena in Ferromagnetic Materials

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THIS ARTICLE presents a new treatment of eddy-current phenomena in solid iron and other ferromagnetic alloys based upon a suggestion by A. G. Ganz.[1] The new treatment is developed logically, beginning with the familiar problem of eddy currents in an infinite region of constant permeability, bounded by a plane surface where excitation is applied. The concepts of phase shift and damping always associated with the space distribution of eddy currents found in this problem are extended to the case in which a ferromagnetic material is used. This material is assumed to have infinite permeability at zero field intensity between positive and negative saturation induction, with zero incremental permeability for all field intensities different from zero. A field theory consistent with the Maxwell theory and preserving the concepts of phase shift and damping is evolved for the assumed material.

The new treatment predicts that prominent time harmonics will be present in both the flux density and the field intensity at any particular depth from the surface of the excited region, when the total flux carried per unit width of surface is sinusoidal. In addition, the phase shift of the fundamental component of flux density at various depths is predicted. These results are compared with those of Rosenberg,[2] who neglected both the phase shift and the time harmonics, and Barth,[3] who included the phase shift but not the harmonics.

Applying the new treatment to problems of induction heating, it is found that the loss (with sinusoidal exciting current) is $4/\pi$ times as great as that predicted by Rosenberg. The increased calculated loss is attributed to the effect of the time harmonics of current density. Also it is found that the power factor of the load reflected into the exciting winding by the eddy currents can be predicted; its value is always slightly less than 90 per cent. The low power factor associated with inductive heating of solid iron can be attributed to the large stray magnetic fields always present.

Previous treatments of eddy currents in solid iron have not yielded a method for computing the power factor of the reflected load as discussed in the previous paragraph. The new treatment arrives at this result by finding the total flux carried per unit of surface width as a function of time, assuming a sinusoidal exciting current. The fact that phase shifts of flux density are taken into account gives this computation meaning. It is found that the emf induced in the exciting winding has a particular waveform independent of the frequency and the amplitude of exciting current (assuming adequate thickness of material to carry the resultant flux). The peak emf varies with frequency and exciting current. The waveform follows the function cos $(\omega t/2)$ during each half-cycle, taking alternate signs, when the exciting current varies as sin (ωt).

This result was checked by observing the waveform and peak value of the emf induced in an exploring coil wound on a closed iron ring which was excited by a sinusoidal current as shown in Fig. 1.

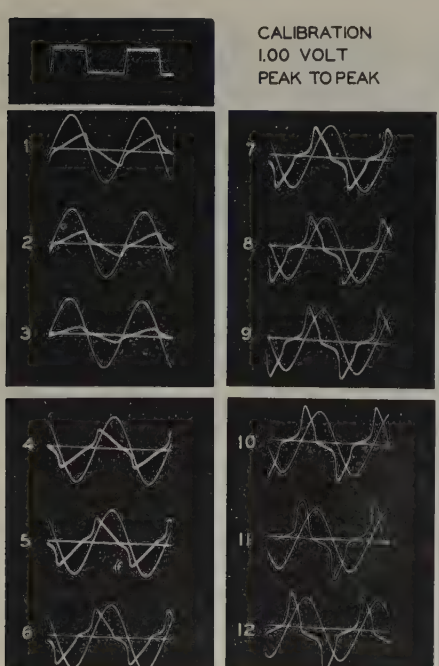

Fig. 1. Induced emf of a search coil wound on a solid iron ring excited with sinusoidal current

The oscillograms are arranged in the order of increasing exciting current, reading from top to bottom on the left followed by top to bottom on the right. The uncalibrated sinusoidal exciting current trace is included for phase comparison. The search coil voltage shows a waveform as predicted by the theory, rising sharply to its maximum value at the beginning of each half-cycle and decaying gradually.

At higher exciting currents than a critical value the depth of penetration of the field becomes larger than the available depth of material. The search coil voltage shows this condition by suddenly dropping to a small value before the end of the half-cycle, signifying that the total flux no longer can increase due to lack of space.

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The Threshold of Perception Currents

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The voltages required for perception with good contacts are low in comparison to the 120-volt house circuits and it is essential that reasonable measures be taken to control leakage currents in household appliances and electrically operated hand tools and thus prevent adverse public reaction to the increasing use of electricity in the home and in industry.

PHYSIOLOGICAL perception of leakage current is important since it is essential that the user does not get the sensation of electric shock when using or touching energized home appliances, electrically operated hand tools, or other portable devices. Currents which are just perceptible are not dangerous; however, when not expected, currents above the perception level are startling or annoying. Currents slightly in excess of an individual's threshold of perception might produce apprehension, fear, or other adverse reaction, and the surprise might be associated with an involuntary movement resulting in loss of balance, a fall, or contact with a dangerous mechanism with serious injury as an aftereffect. For purposes of this discussion, leakage current is defined as that current which under favorable conditions of contact, might be experienced by a person upon contact with the frame or enclosure of portable equipment. The value of such current is dependent upon the normal functioning of the insulation system employed and the normal operating voltage of the equipment, as contrasted with currents which might be experienced as a result of failure of the insulation system of abnormally high operating voltage.

Man is very sensitive to electric current because of his highly developed nervous system, and an almost limitless number of thresholds of sensation could be defined depending upon the locations selected for applying contacts to the body. Many electric shocks are received through contacts made with the hands, and this article is confined to perception of electric current on the hands or fingers. Physiological perception due to electric stimulation depends, to a very considerable extent, upon the type of contacts: whether the contacts are firm and involve appreciable areas, or if they are point contacts. Several different types of contacts will be considered here. Currents almost too small to measure produce piercing pain when they flow in an open cut or wound; however, only data obtained from apparently normal adult male and female subjects having healthy skin are presented here. Emphasis is given to perception of 60-cycle alternating current; however the discussion is concluded with perception limits for both direct current and alternating currents from 60 to 100,000 cycles.

It would appear that the threshold of sensation for small electrodes held in the hand has been fairly well established. Tests made by the author and S. H. Robley* on 114 men in 1940 with the hands resting lightly on No. *7* copper wires yielded an average 60-cycle perception current of 1.072 milliamperes (ma). Dalziel and Mansfield[1] in 1948–49 determined the effect of frequency on perception current, using three contact conditions. The tests, made on 28 men, on 60-cycle alternating current using a No. *8* copper wire held in the hand with the indifferent electrode consisting of a lead strip wrapped with saline-soaked gauze firmly clamped on the associated upper arm yielded a threshold of 1.067 ma. Tests made by the author and R. L. Swenson* in December 1953 on 25 men holding a No. *8* copper wire electrode in the hand with the indifferent electrode, consisting of a saline-soaked arm band on the opposite arm connected in parallel with the associated hand immersed in saline solution, gave a mean value of 1.167 ma. It is believed that the three tests are comparable and the average current just perceptible for a total of 167 adult men between the ages of 18 and 50, when holding No. *7* or No. *8* copper wires in the hand, is 1.086 ma.

THRESHOLD OF PERCEPTION

THROUGHOUT these investigations an individual's threshold of perception is taken as the mean value of current just causing sensation when using a subthreshold approach; that is, with gradually increasing current. The threshold of perception for a group is taken as the mean value for the group. Experimental points using the No. *7* or *8* copper-wire electrodes held in the hand for 60-cycle sine-wave alternating current for the 167 men are shown in Fig. 1. The curve determined by the majority of the points is called the distribution curve, and it is to be noted that the response is a straight line on the probability graph paper. This indicates that a sufficient number of subjects were tested to permit valid predictions to be made, not only for the group tested, but for a large sample of the normal adult population. It is apparent that perception levels corresponding to any given percentage of the group can be taken directly from the curve.

Such tests are time consuming, and somewhat smaller groups were used to investigate other contact conditions. For example, Fig. 2 gives the deviation curve with the middle finger touching and tapping a flat polished copper plate.[1] The touching tests were made with the tip of the middle finger resting lightly on the plate; for the tapping

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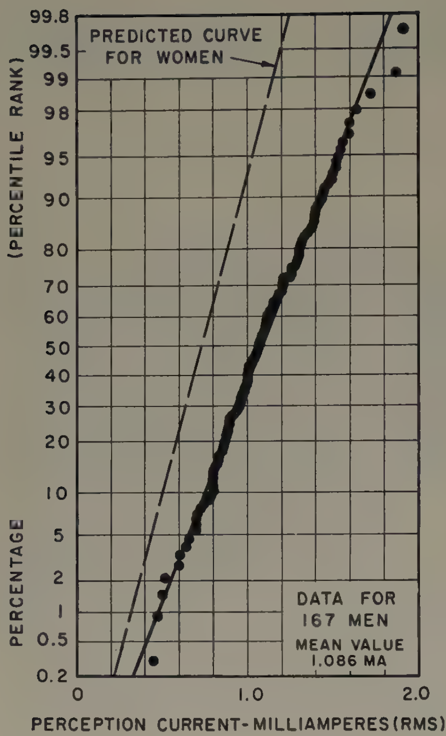

Fig. 1. 60-cycle perception distribution curve. Hand holding small copper wire

tests the tip of the middle finger contacted the plate at a rate of once or twice a second. The circuit was completed by means of the arm band clamped around the upper arm. The threshold values for 25 men were 0.363 and 0.361 ma respectively. Here the data are plotted as per cent deviations from the mean of each group, and the straight-line response is called the deviation curve. This method of expressing data for electric stimulation is of value in analyzing the results, since deviation curves obtained from similar tests have essentially the same slopes whereas the corresponding distribution curves generally have different slopes.

In Table I are summarized the results for a group of 26 men when grasping the flexible portion of an aluminum desk lamp as one would do to shift its position on a table top, when holding a 1/4-inch $4^3/_4$-pound pistol-grip drill vertically as one would do to drill a hole in a horizontal surface, and when touching with the middle knuckle the chromium-finished top of a waffle iron. In these tests the current pathway was between the hands; the indifferent electrode consisted of the saline-soaked arm band connected in parallel with the left hand which was immersed in saline solution. Per cent deviations at the $99^1/_2$ and 1/2 percentiles and the range of resistances are included in the table. Deviation values for the test made on the waffle iron are not given because the response failed to follow a normal distribution. This finding was not unexpected, as the large variation in currents, voltages, and resistances of the body circuit together with the differences in reported sensations, confirm the common observation that the general condition and sensitivity of the skin in the crease of the knuckle joint varies widely among individuals. Since the 26 men used in these tests represent a substantial sample, the results may be of value in establishing realistic perception limits for portables in common use.

Gordon Thompson, in 1933, published results of perception tests made on 70 adult personnel of the Electrical Testing Laboratories, New York, N. Y.[2] Of this number 28 were women and 42 were men. In these investigations the left hand was immersed in a weak saline solution, and the right hand completed the circuit according to the type of test. A tapping test was made in which the right forefinger contacted a metallic surface with the tip of the finger; a metallic surface was pinched with the thumb and forefinger up to the first joint; a long cylindrical metal rod 1 inch in diameter was grasped with the right hand; the right hand was also immersed in salt water up to the wrist. Experimental values obtained by Mr. Thompson are given in Table II. It is observed that the results are consistent with the more recent observations made at the University of California.

This work is valuable, as the perception ratio women/men = 67 per cent, can be applied to the other tests made only on men to predict corresponding values for females for the other contact conditions. The slightly greater sensitivity of women is probably due to woman's more sensitive nervous system rather than to any difference due to sex.

PERCEPTION THRESHOLD DEPENDS ON CONTACT AREA

From the experimental results given in the foregoing, it is apparent that the threshold is somewhat dependent upon the amount of contact area. The threshold increases slightly with the area in contact with the skin, but in an indeterminate way. Piercing pain is experienced when the skin is broken as in an abrasion, hang nail, cut, or wound. However, except when the current density at the point of contact is relatively high as in the touching or

Table I. 60-Cycle Perception Currents and Voltages When Holding or Touching Various Portables

Summary of Data Obtained on 26 Men

	Holding Desk Lamp			Holding Drill			Touching Waffle Iron		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Milliamperes, rms	0.6	1.13	2.0	0.6	1.20	1.8	0.1	0.39	0.9
Volts, rms	1.0	2.2	5.4	1.0	2.10	3.8	2.5	8.35	19.0
Resistance, ohms	1,200	1,970	3,600	1,160	1,810	2,970	7,150	24,600	45,500
Deviation from mean at $99^1/_2$–$^1/_2$ per cent		±0.70			±0.63				

Table II. 60-Cycle Perception Tests Conducted at the Electrical Testing Laboratories

Type of Contact	28 Women Minimum Ma	28 Women Mean Ma	28 Women Maximum Ma	42 Men Minimum Ma	42 Men Mean Ma	42 Men Maximum Ma	Ratio of Mean Values Women/Men
Tap	0.20	0.27	0.40	0.20	0.40	0.80	0.675
Pinch	0.20	0.59	1.20	0.26	0.87	2.40	0.678
Grip	0.50	0.84	1.40	0.28	1.19	3.00	0.706
Immersion	0.30	0.88	1.80	0.44	1.39	3.00	0.633
Perception ratio, women/men							0.67

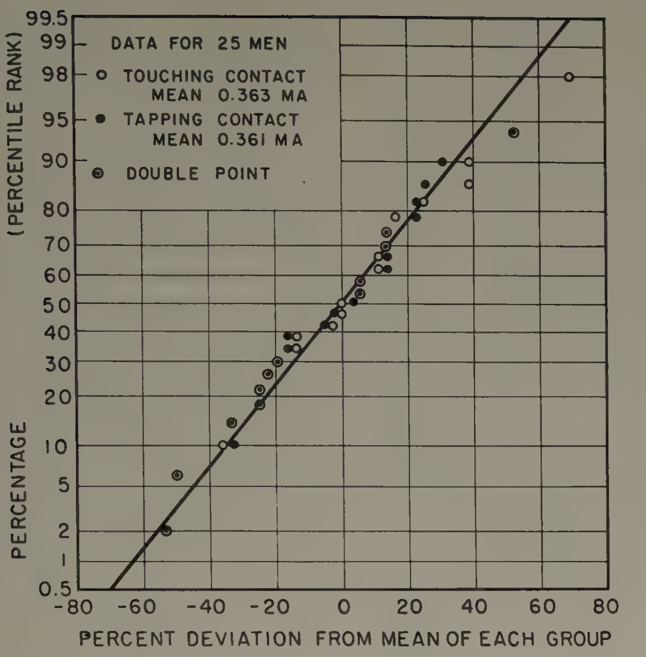

Fig. 2. 60-cycle perception deviation curve. Tip of middle finger touching or tapping polished copper plate

tapping tests, the effect is small and it is believed to be of minor practical importance. For example, it was found that the area of the indifferent electrode must be relatively large to assure that the first sensations will occur at the test electrode. In the tests just concluded, the first sensations often occurred at the arm band indifferent electrode. This effect was observed most frequently when the arm band was placed on the same limb as that used to hold the test electrode. The effect was less frequent when the arm band was placed on the opposite arm, and nearly eliminated when the arm band was connected in parallel with the hand immersed in the saline solution. In several instances the sensations were observed concurrently at both points of contact, and in a few cases the electrodes were interchanged and the left hand used to hold the test electrode in order that the first sensations would occur at the site of the test electrode. Although the threshold increases with the area of contact, large areas apparently often have imperceptible surface irregularities which tend to nullify the area effect. It is believed that the responses for the various types of test electrodes are typical of the contacts likely to be experienced in practice.

An attempt was made to determine the effect of waveshape on perception current, and Table III gives a summary of rms voltages and currents for various waveforms with the hand holding the No. *8* copper wire. Oscillograms of some of the waveforms which were obtained from a dual-beam-type cathode-ray oscillograph, are given in Fig. 3. In each case the upper trace is the voltage across the subject, and the lower trace is the current through the subject with the crest of the wave held at approximately 2 ma. Table IV gives detailed results of the study, and the consistency of the mean crest values for the five waveforms is submitted as substantiating the opinion that the crest of the wave, and not the effective or average value, is the controlling factor in nerve stimulation. Photographs of one of the volunteer subjects in the process of determining his perception current and some of the testing equipment, and also of the various test electrodes used in the investigations of December 1953, are given in Fig. 4. It is anticipated that these photographs may serve to answer questions not adequately covered in the text.

Although perception of 60-cycle alternating current is the chief concern of this article, the effects at other frequencies may be of interest for specific problems. The direct-current perception distribution curve of Fig. 5 was obtained in the tests made in 1940 on 115 men. For these tests, the hands were placed lightly on No. *7* copper wires and the direct current was controlled from a potentiometer energized from batteries. The threshold value was 5.2 ma. Fig. 6 was obtained during the tests of 1948–49 to determine the effect of frequency on perception currents in which sine-wave currents from 60 to 100,000 cycles were used. Reference 1 should be consulted for a more complete discussion of the phenomena of perception at the higher frequencies.

Before testing an individual, the areas to which contacts were to be applied were wet with a salt-water solution. This procedure is desirable for several reasons, the most important being that it permits the use of low voltage for safety. Wet contacts minimize variations in skin and contact resistance, stabilize the circuit, and permit adequate control of the current. A few preliminary perception tests, with the knuckle touching the waffle iron, were made with normal dry skin. It was observed that practically no current would flow until the skin broke down. At this

Table III. 60-Cycle Perception Currents and Voltages for Various Waveshapes With Hand Holding No. 8 Copper Wire

Summary of Data Obtained on 25 Men

	Sine Wave			Peak Wave			Dimple Wave		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Milliamperes, rms	0.5	1.17	1.8	0.5	0.96	1.6	0.5	1.32	2.1
Volts, rms	2.0	3.50	8.0	2.1	3.56	7.2	2.0	3.29	7.5

	Triangular Wave			Square Wave		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Milliamperes, rms	0.5	0.95	1.5	0.8	1.56	2.4
Volts, rms	2.0	3.58	8.0	1.0	2.87	6.0

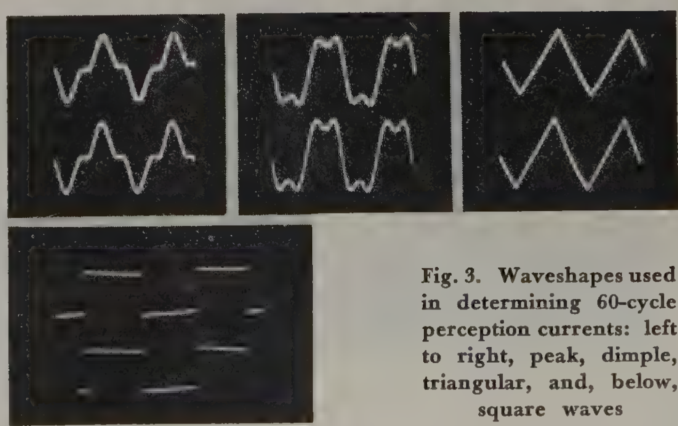

Fig. 3. Waveshapes used in determining 60-cycle perception currents: left to right, peak, dimple, triangular, and, below, square waves

Table IV. Effect of Waveform on 60-Cycle Perception Current With Hand Holding No. 8 Copper Wire

Data for 25 Men

	Sine Wave (Ma)			Peak Wave (Ma)			Dimple Wave (Ma)			Triangular Wave (Ma)			Square Wave (Ma)		
	Crest	Rms	Avg	Crest	Rms	Avg	Crest	Rms	Avg	Crest	Rms	Avg	Crest	Rms	Avg
	2.51	1.77	1.59	2.72	1.57	1.22	2.57	2.06	1.95	2.64	1.48	1.30	2.58	2.41	2.44
	2.15	1.52	1.37	2.36	1.36	1.06	2.22	1.77	1.68	2.33	1.31	1.16			
	2.15	1.52	1.37	2.08	1.20	0.93	2.29	1.83	1.73	2.15	1.21	1.06	2.32	2.17	2.20
	2.12	1.50	1.35	2.10	1.21	0.94	1.78	1.41	1.34	1.83	1.03	0.91	1.86	1.74	1.76
	2.00	1.42	1.28	1.93	1.11	0.86	2.09	1.66	1.58	2.04	1.14	1.01	2.10	1.97	1.99
	2.00	1.42	1.28	2.02	1.16	0.90	2.02	1.61	1.53	2.07	1.17	1.03	2.02	1.89	1.91
	1.93	1.37	1.23	1.90	1.10	0.85	1.86	1.48	1.41	2.00	1.13	0.99	1.72	1.61	1.62
	1.93	1.37	1.23	1.98	1.14	0.88	2.00	1.60	1.52	2.22	1.25	1.10	2.15	2.02	2.03
	1.86	1.32	1.18	1.82	1.05	0.81	1.86	1.48	1.41	1.89	1.06	0.94	1.86	1.74	1.76
	1.83	1.30	1.17	1.76	1.02	0.79	1.86	1.48	1.41	1.88	1.05	0.93	1.92	1.79	1.81
	1.79	1.27	1.14	1.66	0.96	0.74	1.79	1.43	1.36	1.98	1.11	0.98	1.89	1.77	1.79
	1.76	1.25	1.12	1.86	1.07	0.83	2.04	1.63	1.55	1.82	1.02	0.90	1.72	1.61	1.62
	1.72	1.22	1.09	1.86	1.07	0.83	1.89	1.50	1.43	1.79	1.01	0.89	1.77	1.66	1.68
	1.60	1.13	1.02	1.55	0.89	0.69	1.65	1.31	1.25	1.58	0.88	0.78	1.47	1.38	1.40
	1.57	1.12	1.00	1.72	0.99	0.77	1.72	1.37	1.30	1.72	0.97	0.85	1.77	1.66	1.68
	1.55	1.09	0.98	1.55	0.89	0.69	1.58	1.25	1.19	1.62	0.91	0.80	1.63	1.53	1.54
	1.52	1.07	0.97	1.49	0.86	0.67	1.43	1.14	1.08	1.59	0.89	0.79	1.58	1.47	1.49
	1.40	0.99	0.89	1.32	0.76	0.59	1.32	1.05	1.00	1.17	0.66	0.58	1.32	1.23	1.25
	1.38	0.97	0.87	1.46	0.84	0.65	1.22	0.97	0.92	1.43	0.81	0.71	1.82	1.70	1.72
	1.36	0.96	0.86	1.36	0.78	0.61	1.36	1.08	1.03	1.50	0.85	0.74	1.45	1.35	1.37
	1.30	0.92	0.83	1.32	0.76	0.59	1.33	1.06	1.01	1.16	0.65	0.57	1.18	1.10	1.12
	1.25	0.88	0.79	1.07	0.62	0.48	1.03	0.82	0.78	1.04	0.59	0.52	1.04	0.98	0.99
	1.00	0.71	0.64	0.80	0.46	0.36	0.93	0.74	0.70	0.93	0.52	0.46	0.87	0.82	0.83
	0.90	0.64	0.57	0.86	0.50	0.38	0.96	0.76	0.73	0.93	0.52	0.46	0.93	0.87	0.88
	0.73	0.52	0.46	0.90	0.52	0.40	0.69	0.55	0.52	0.93	0.52	0.46	0.97	0.91	0.92
Mean	1.65	1.17	1.05	1.66	0.96	0.74	1.66	1.32	1.26	1.69	0.95	0.84	1.66	1.56	1.58

instant, several milliamperes would flow causing off-scale deflections of the instruments, and considerable discomfort to the subject. These undesirable effects were eliminated when the knuckle was wet. Subsequent tests were conducted with the knuckle moist (not dripping wet). Similar results were observed in the touching and tapping contact tests. The voltages given in Tables I and III with wet or moist contacts are so low in comparison with 120- or 240-volt house circuits, that the probability of receiving perception from appliances or other portables having low insulation resistance during favorable contact conditions is obvious.

The impedance of the human body is predominately resistive at low frequencies; however, capacitive effects become important at the higher frequencies. The practical effect is that for given contact conditions, as the frequency increases the body impedance decreases and the voltages required to cause perception increase at a smaller rate than the current versus frequency curves of Fig. 6. Capacitive effects may be important at higher frequencies for waveshapes having appreciable harmonic content, and for pulses. However, man's decreasing sensitivity with increasing frequency suggests that the effect of higher harmonics, or repetitive pulses superimposed on low- frequency alternating current, would have less and less stimulating effect as the frequency of the superimposed current is increased. Above 100 to 200 kc it might be expected that the sensation of heat produced by the high-frequency components would be largely masked out by the nerve stimulation caused by the lower-frequency components.

In cases where asymmetrical waveforms are present both direct and reverse readings must be taken to ascertain the maximum crest value of the a-c component. Where composite waves consisting of alternating components superimposed on direct components are involved, an analysis similar to that given for the derivation of the curves of Fig. 2, reference 3, might be employed. In this case the threshold-perception-current curve for small wires held in the hands should be drawn parallel to the curves of the figure, but using $1.086 \times \sqrt{2}$ ma for the crest of the alternating component and 5.2 ma for the direct component.

HUMAN BODY RESISTANCE

It has been stated by H. B. Whitaker[4] that the resistance of thoroughly dry skin on the hands may have a range of 40,000 to 50,000 ohms per square centimeter. In contrast, the skin resistance may drop to as low as 1,000 ohms per square centimeter when the hands are wet. In practice the surface moisture condition of the hands may vary widely. A housewive using a drink mixer in the kitchen sink or sprinkling clothes prior to ironing in a wet laundry room, or a perspiring mechanic soldering a leaky

Fig. 4. Determination of 60-cycle perception currents: left to right, No. 8 copper wire, desk lamp, waffle iron, and hand drill

water pipe exemplify different moisture conditions of the hands. Obviously, wet hands within reach of well-grounded objects create a most dangerous condition for receiving an electric shock.

The lowest resistance of the body circuit likely to be present during casual contact involving currents of the perception level is important, not only for scientific purposes, but also for establishing the maximum allowable resistance for instruments to be used for the measurement of leakage currents in commercial practice. K. S. Geiges[5] established this resistance at 1,500 ohms, in connection with the measurement of leakage currents in radio receivers.[6] The minimum and mean resistance values of Table I confirm that the 1,500-ohm value is a reasonable compromise. Currents at the perception level are too feeble to produce burns or other major breakdown of the skin at the contact locations, and it is unlikely that in casual contact the connection with the other side of the circuit would develop as low resistances as the minimum values achieved in these experiments.

MEASURING EQUIPMENT

INSTRUMENTS for measuring currents at the low values just causing perception were not readily available, and the following instruments were connected in series: a peak responsive vacuum-tube voltmeter (General Radio Type *726* or *1803A*) connected in shunt to a 1,000-ohm noninductive resistor, a 0–10-ma oxide rectifier milliammeter (General Electric Type *DS-6*), and a 0–5-ma thermal milliammeter (Sensitive Research Model "University"). The last-named instrument was calibrated with the laboratory standard using direct current and was subsequently used as a sub-standard. The comparative readings of the three instruments at 4.00 rms ma permitted determining multiplying factors to be applied to the vacuum-tube voltmeter readings to obtain the crest, effective, and average values given in the tables. This procedure was desirable since the vacuum-tube voltmeter was provided with a 0–1.5-volt scale, which permitted accurate observations not possible with the other instruments.

Since all portable equipment has some distributed capacity, and large numbers are provided with capacitors for suppressing radio interference, it is suggested that preference be given to instruments having negligible inductance. An inductive instrument used to measure leakage current might cause partial series resonance, thereby causing the instrument to read too high, or its impedance to higher frequencies might suppress the harmonics and cause it to read too low. Either of these effects would result in an erroneous indication.

In attempting to establish perception levels it should be realized that the subjects concentrated their complete attention on the first perception of sensation due to electric stimulation. Without exception, perception of the first sensations, which have been variously described as tingling, throbbing, pricking, or heating sensations, are quite difficult to detect. The value for an individual was assigned only after several trials in which reasonably consistent values were obtained, and wild values were disregarded to eliminate effects of imagination. For these reasons, an individual's perception current should be regarded as conservative. In unsuspecting contact an individual's attention would be focused on other matters, and it is likely that considerably larger currents, possibly up to twice his threshold current, might not be noticed. It is suggested that these intangible factors be given consideration in establishing realistic perception thresholds for purposes of standardization.

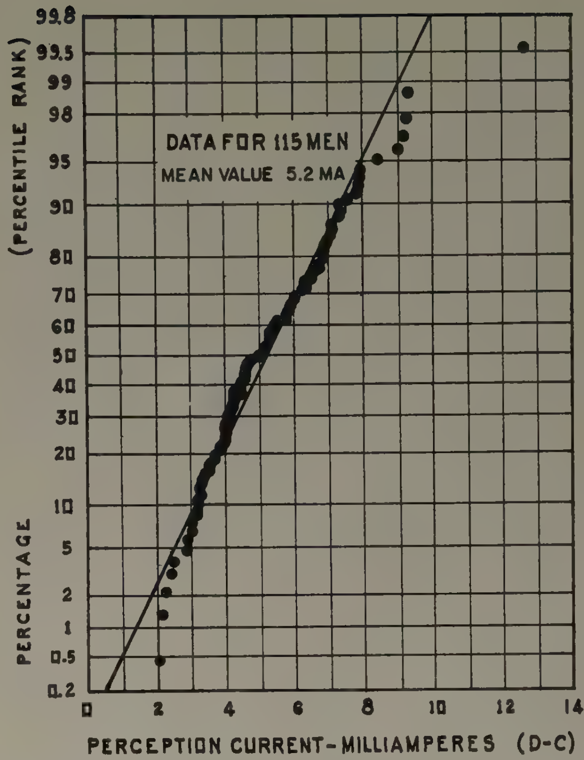

Fig. 5. Direct-current perception distribution curve for hand holding small copper wire

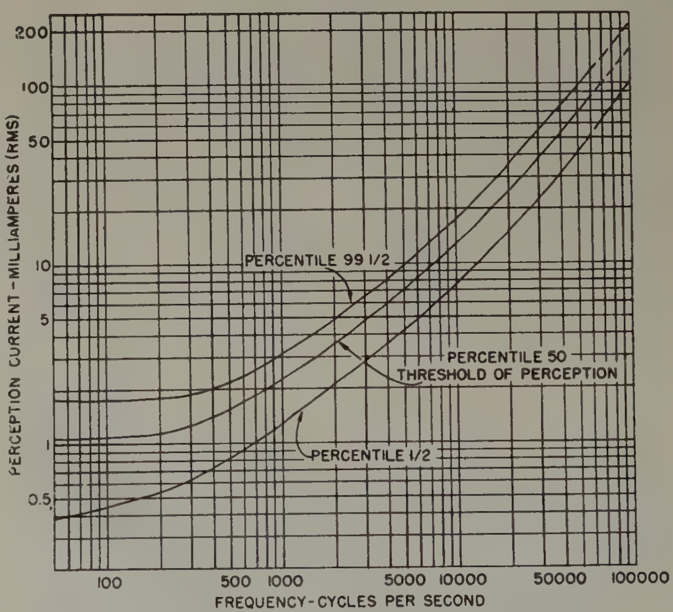

Fig. 6. Effect of frequency on perception using sine-wave current with hand holding small copper wire

CONCLUSION

PHYSIOLOGICAL perception of leakage current is important since it is essential that the user does not get the sensation of electric shock when using home appliances, electrically operated hand tools, or other portable devices. Perception of 60-cycle alternating current has been determined for several different types of contacts held in the hands, with fingers touching or tapping metallic surfaces, and with the knuckle or finger tip touching a polished metal surface. Perception currents with hands holding a small copper wire were determined for pure direct current, and for alternating currents from 60 to 100,000 cycles per second and with various waveforms. It is believed that a sufficient amount of data obtained from healthy male and female subjects are presented to permit valid predictions of the currents likely to be perceived, or those not likely to be perceived, for large groups of normal adults having healthy hands. In addition to the tabulated data, the results are presented in the form of curves which permit estimating perception levels for various percentages of a large group. The voltages required to cause perception with wet contacts are very low. Therefore, it is essential that the public be protected against perception currents by proper design, adequate materials, and careful assembly, so as to prevent the probability of adverse public reaction in the use of home appliances or other portable equipment.

Appendix

Predicted perception current threshold for women for the tapping copper-block contact is computed as follows:

Mean for women = (Perception ratio women/men)(Mean for men)
= $0.67 \times 0.361 = 0.242$ ma
(Perception ratio women/men = 0.67 from Table II)
(Mean value for men for tapping copper block = 0.361 from Fig. 2.)

Predicted $99^1/_2$ or 1/2 percentile values for women tapping a metallic surface are computed as follows:

Milliamperes = (Mean of group)(1.0 ± Deviation from mean corresponding to percentile rank desired)
= $0.242\ (1.0 \pm 0.70) = 0.41$ or 0.07 ma
(Deviation from mean at $99^1/_2$ or 1/2 per cent = ±0.70 from Fig. 2.)

Predicted distribution curve for women for holding small copper wire is derived as follows:

Mean for women = $0.67 \times 1.086 = 0.728$ ma
(Perception ratio women/men = 0.67 from Table II)
(Mean value for men for holding small copper wire is 1.086 from Fig. 1.)

$$\text{Deviation from mean at } 99^1/_2 \text{ per cent} = \frac{1.77-1.086}{1.086} = +0.63$$

(From Fig. 1)

Predicted $99^1/_2$ per cent value for women = $0.728\ (1+0.63) = 1.19$ ma

$$\text{Deviation from mean at } 1/2 \text{ per cent} = \frac{0.402-1.086}{1.086} = -0.63$$

(From Fig. 1)

Predicted 1/2 per cent value for women = $0.728\ (1-0.63) = 0.27$ ma. The dashed line drawn through these points ($99^1/_2$, 50, and 1/2 per cent) of Fig. 1 is the predicted distribution curve for women.

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Air-to-Air Guided Missile Can Be Fired by Jet Planes

U. S. Navy photo

Sperry Sparrow air-to-air guided missiles, poised on wing racks of the Navy's twin-jet night fighter, the Douglas F3D Skynight

Advanced status of a U. S. Navy air-to-air guided missile system, the supersonic Sparrow I, has been announced by the Department of Defense. Announcement was made after more than 7 years' development by the Navy Bureau of Aeronautics and the Sperry Gyroscope Company.

Defense and Navy officials decline to specify details of the missile types selected for first and second phase production runs, other than stating that these systems are capable of accurate control when the missile is fired from a speeding jet plane.

The Sperry Sparrow is rocket powered and fully maneuverable at supersonic speeds, yet light and compact enough to be carried in multiple units by fighter-type carrier-based jet aircraft. Exact weight, range, type of warhead, and performance data are still classified.

Necessary training of personnel is underway for operational use of this weapon by the fleet.

Co-ordination of Fuel Cost and Transmission Loss

W. R. BROWNLEE
FELLOW AIEE

A NUMBER OF METHODS have been described for developing a set of loss constants for a power system network with which the total or incremental losses can be calculated by matrix multiplications. These values then may be applied to the dispatching of power systems through comparisons of incremental fuel costs and incremental transmission losses. A new approach determines the per unit incremental loss incurred by increasing the generation at one plant by a small amount and reducing the generation at another plant by the amount required to maintain constant loads. This per unit incremental loss then is compared with the ratio of the incremental fuel costs of the two plants, complete co-ordination being provided by the economic balancing of pairs of plants. The two basic assumptions are in harmony with practicable power system operation. They are

1. When small amounts of power are exchanged between generating plants of a power system, the magnitudes of the bus voltages of these plants are unchanged.
2. Multiple transmission paths between any two generating plants may be represented by a single impedance, commonly known as the transfer impedance.

From these assumptions, equations have been developed showing that the incremental loss incurred by increasing generation of a plant by a small amount and decreasing another by an appropriate amount to maintain constant loads is

$$dL/dP_{1-2} = (2 \tan \theta_{1-2})/(K + \tan \theta_{1-2}) \tag{1}$$

where θ_{1-2} is the angle by which the voltage at plant 1 leads that of plant 2, and K is the ratio of reactance to resistance of the open-circuit transfer impedance between these plants. This formula is rigorous except for the influence of intermediate plants, which tend to maintain constant voltages at points along the path. A more accurate expression recognizing the presence of intermediate plants is

$$dL/dP_{1-2} = (4K \tan 1/2\ \theta_{1-2})/(K + \tan 1/2\ \theta_{1-2})^2 \tag{2}$$

Co-ordination of incremental fuel costs and incremental transmission losses then is expressed as:

$$\frac{dF_2/dP_2}{dF_1/dP_1} = \frac{(K + \tan 1/2\ \theta_{1-2})^2}{(K - \tan 1/2\ \theta_{1-2})^2} \tag{3}$$

where dF_1/dP_1 is the incremental fuel cost of plant 1. Fig. 1 illustrates the variation of economic fuel cost ratio with the angle θ for three values of K. With such a series of curves and with tables or curves of incremental fuel costs, it is feasible to adjust the generation represented on a network analyzer in a rapid series of approximations.

Equations for deriving incremental losses may be expanded to deal with substantial exchanges of generation. Fig. 2 includes a curve plotted from such equations together with the corresponding losses determined by I^2R summations and also by means of B constants.

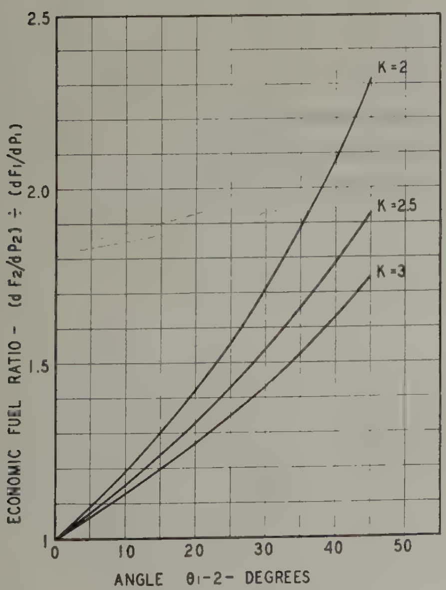

Fig. 1. Economic fuel cost ratio as a function of phase angle and reactance/resistance ratio, K

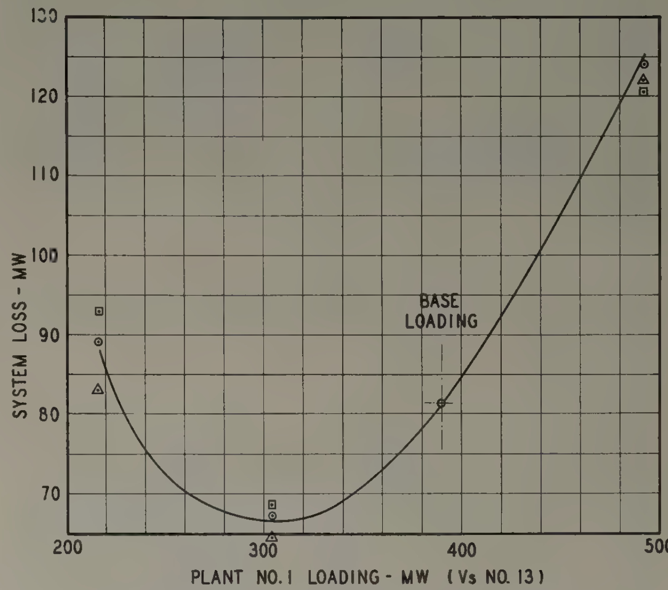

Fig. 2. System loss changes with exchanges in generation between plants 1 and 13

Curve plotted from angle equations
⊙ = *I^2R calculated values*
△ = *Calculated from B constants*
⊡ = *From modified B constants*

Digest of paper 54-65, "Co-ordination of Incremental Fuel Costs and Incremental Transmission Losses by Functions of Voltage Phase Angles," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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Let's Reduce the Cost of Lighting

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To determine how money can be saved on lighting, two main factors should be considered: the cost of the installation and the cost of its maintenance. The elements comprising these factors are discussed and formulas are given which should assist in the choice.

"HOW CAN I reduce the cost of my lighting?" This question is asked by two types of people: the man who is contemplating the purchase of a lighting system and the man who already owns one. The second man is interested in reducing his maintenance costs while the first man is interested in obtaining a quality lighting system as economically as possible. Other things being equal, the purchaser is concerned mainly with how much money he will have to invest in a lighting system and how much his electrical bill will be each month. The maintenance of the lighting system, while an important consideration to the purchaser, is not as important to him as it will be after he has installed the lighting.

In order to analyze the economics of lighting, therefore, it may be well to investigate first the cost considerations of choosing a lighting system, and second the cost considerations of maintaining a lighting installation.

It should be remembered in this discussion, that costs are only one consideration in the choice of a lighting system. Other things such as comfort, uniformity, appearance, are very important in making a decision as to the type of lighting to be chosen.

CHOOSING A NEW LIGHTING SYSTEM

ECONOMICALLY the annual cost of a lighting system is composed of several costs: amortized investment, energy costs, lamp costs, and the maintenance costs of cleaning and lamp replacement. Since each of these has to be considered, the relative merit of each and its effect on the total is important. Just what percentage of the total each factor will be depends upon the lighting system chosen. Table I gives some idea of the ranges to be expected, while Table II shows the percentages of three typical lighting systems.

Revised text of conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, and recommended for publication by the AIEE Committee on Production and Application of Light.

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Table I. Breakdown of Lighting Costs

	Percentage of Total Annual Cost
Amortized investment (includes wiring)	10–30
Energy costs	60–80
Lamp costs	5–30
Maintenance (total)	(2–20)
1. Fixture cleaning	0–15
2. Labor of lamp replacement	1–10

Table II. Relative Lighting Costs for Three Typical Lighting Systems (Approximate)

	Type of Installation		
	1,000W-PS52 Incandescent	2-96T12 Fluorescent	2-H400E1 Mercury
Amortized investment (includes wiring)	11%	27%	16%
Energy costs	80%	60%	68%
Lamp costs	6%	8%	14%
Maintenance	(3)	(5)	(2)
1. Fixture cleaning	1	4	1
2. Labor of lamp replacement	2	1	1
Total annual lighting costs	100%	100%	100%
Approximate total annual lighting costs for equal maintained foot-candles 2 shift 2¢	1	2/3	2/3

Fig. 1. The R-52 reflectorized lamp is designed for applications where dirt and dust conditions are severe

It is important to keep in mind in this discussion that no comparison is made as to which light source is most economical for any particular lighting level. This would depend on the particular situation as each lighting system has variables—such as mounting height, burning hours, energy rates, fixture costs, and labor rates. This discussion is concerned only with the percentage of total annual costs that may be expected from each factor of a particular lighting system. An analysis of these percentages, then, shows which factors are the most important from an economical standpoint for a particular lighting system.

Consider first the amortized investment costs (including wiring). Generally low percentages can be expected from filament and mercury installations because they produce a large package of light from a small source. Fluorescent fixtures on the other hand are usually larger

than filament or mercury because fluorescent lamps are lower in brightness. Therefore, the amortized investment of fluorescent lighting generally will be a higher percentage of its total annual costs than either filament or mercury. This factor has to be considered when there are only limited funds available for investment.

On the other hand, the energy costs of fluorescent lighting systems are usually a lower percentage of total annual costs than the energy costs of the other systems are of their total costs. This can be explained by the facts that fluorescent lamps are the most efficient producers of light and their fixtures are large compared to the package of light the fluorescent lamps produce. Filament lamps are on the other end of the scale because of their poor efficiency and their relatively low fixture costs. Obviously, if the energy rates are quite high, filament energy costs would suffer.

Lamp costs vary over a surprisingly wide range in their percentage of total costs. On the low end are the filament lamps because of their relatively low cost as against high light output. On the high side are the mercury lamps: compare the cost of a 1,000-watt *PS-52*, $3.75, as against an *H400E1* mercury lamp, $17.00 (both produce approximately the same amount of light). This is one important reason why group relamping of mercury lamps is seldom economical, whereas group relamping of filament lamps usually is. This fact will be discussed in the section on maintenance.

MAINTENANCE COSTS

After a lighting system is installed, the only variable is maintenance. Maintenance of a lighting system includes cleaning of fixtures, replacement of lamps, and some electrical repair. Since electrical repair is generally such a small and unpredictable part of maintenance, it is not discussed here.

Cleaning costs can be a very small part of the maintenance costs or a very large part. If a lighting system with reflectorized lamps is chosen (see Fig. 1), the cleaning costs approach zero since collection of dust and dirt on the sides of the lamps has no effect because the reflector is sealed inside the bulb; for example, the foundry shown in Fig. 2. On the other hand, where lighting equipment which has reflectors exposed to the air is installed in very dirty locations such as foundries, the cleaning costs can be quite high. Many tests have shown that ventilation holes or openings in the tops of the light fixtures tend to reduce dirt and dust accumulation on the reflecting surfaces, as illustrated in Fig. 3. The heat of the lamps causes convection currents which carry dust and dirt up past the reflector and out the openings in the top of the fixture, see Fig. 4.

Labor cost of lamp replacement is another aspect of maintenance which is quite variable. Variations are caused by differences in labor rates and in the difficulty of getting to the lamps to replace them. Consider how costly it is to replace lamps on a radio tower compared to the cost of changing an incandescent lamp mounted 8 to 10 feet from the floor. For this reason, the typical ranges shown in Table I are often exceeded.

Fig. 2. For plants like this foundry where it is hard to keep reflectors clean, lamps like that shown in Fig. 1, with the reflector sealed inside the bulb, reduce maintenance costs

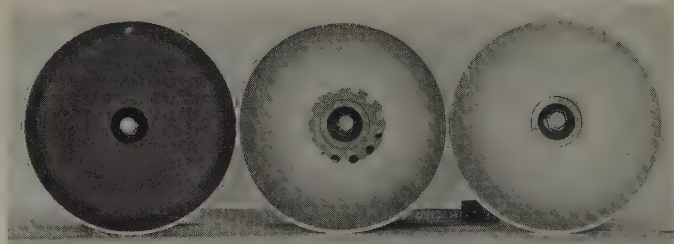


Fig. 3. These reflectors were exposed in the same industrial area for about 1 year. The reflector on the left shows how dirt collects when no ventilation is incorporated. The middle reflector shows the effect of ventilating holes placed near the neck of the reflector, while the one on the right shows a small amount of dirt on the reflecting surface when the holes are in the neck of the reflector

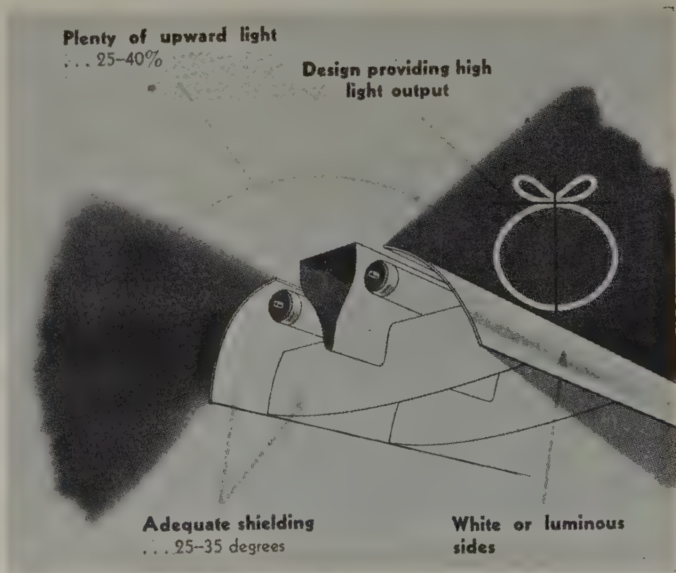


Fig. 4. Prototype of a new type of industrial fixture with open top said to be most suitable to achieve higher illumination levels comfortably

In order to reduce the labor cost of lamp replacement, a group relamping program is often used. See Fig. 5. Group relamping is a mass production method of replacing lamps before the lamps reach their rated life. This eliminates most of the travel time and setup time required to change lamps individually as they burn out. The labor costs saved by group relamping usually more than compensate for the value of the depreciated lamps that are thrown away. It is usually desirable to group relamp filament and fluorescent lighting installations, but seldom feasible to group relamp mercury systems. The main reason for this is that mercury lamps are more expensive, as was mentioned previously; thus, the labor costs saved by group relamping are seldom enough to offset the value of the depreciated lamp that is discarded.

It is relatively easy to determine whether group relamping will save money, if the labor cost of spot replacement is known and the labor cost of group relamping can be estimated. First, it is important to understand how the two general types of group relamping plans work.

Plan 1. From the fluorescent lamp mortality curves it can be determined that at 80-per-cent average life there are approximately 20-per-cent burnouts.

1. Set aside the best 20 per cent of the old lamps while still in the fixture, to use as spares. (Pick out the cleanest, brightest lamps while lighted.)
2. Put new lamps in all sockets.
3. Replace individual lamps as they burn out, using the stock of spares.
4. When all spares are used up, repeat the cycle.

Plan 2. From the fluorescent lamp mortality curves it can be determined that at 70-per-cent average life there are approximately 10-per-cent burnouts.

1. Replace all lamps with new ones.
2. After 10 per cent are burned out (and left in the sockets) replace all lamps again.

This plan is only feasible in large areas where each location receives light from several fixtures so that the burnouts left in the sockets do not affect coverage greatly. See Fig. 6.

With a knowledge of these two group relamping plans, their costs can be determined and compared to the spot replacements costs with the following formulas:

For spot replacement:

$$C=L+S$$

For group relamping, using selected lamps as interim replacements:

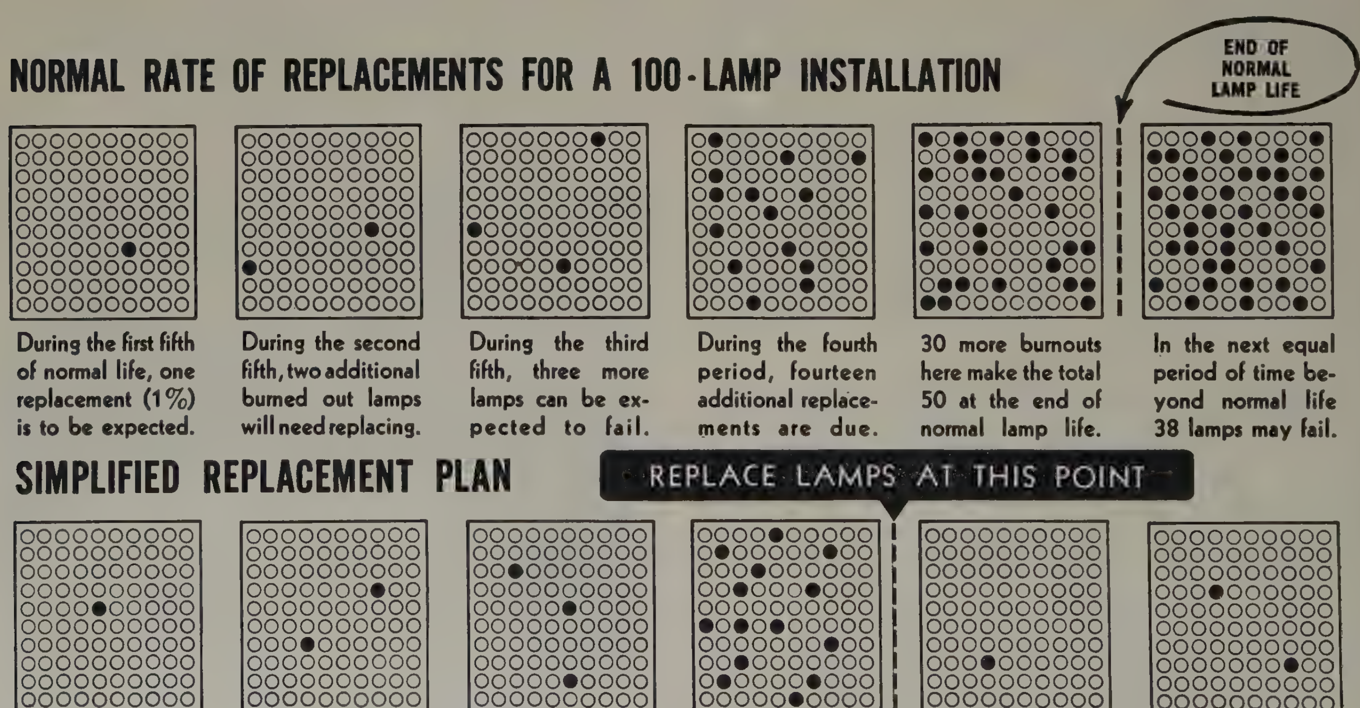
$$C=\frac{L+G+(B\times S)}{I}$$

For group relamping, with no interim replacements:

$$C=\frac{L+G}{I}$$

Key to symbols:

C=Total cost of lamp replacement per lamp life.
L=Lamp net price, including Federal Excise Tax.
S=Spot replacement labor cost per lamp.
G=Group-relamping labor cost per lamp.
B=Per-cent burnouts at end of group-relamping interval (from mortality curve).
I=Group-relamping interval in terms of average lamp life.



UNDER THE SIMPLIFIED lamp replacement plan, the periods involving the greatest number of lamp replacements, work interruptions, etc. are avoided. Here's how: when a total of twenty per cent of the original lamps have failed, the entire installation is re-lamped. The best 20 per cent of the lamps removed are saved to be used as spares. When the stock of spares has been used it's time to relamp again.

Fig. 5. A group lamp replacement plan by means of which maintenance time and money can be saved

Fig. 6. The second plan discussed can be tried in an area lit like this because of the multi-unit arrangement of the fixtures

From an analysis of these formulas, a number of interesting facts can be obtained.

1. The value of *B*—per-cent burnouts at end of group relamping interval—has to be low and/or the value of *I*—group-relamping interval in terms of average life—has to be fairly high in order to have a low group relamping cost. This means that group relamping is not practical where the quality of lamps is poor. The mortality curve has to be steep. In other words, a high percentage of lamps should burn out near rated life and a low percentage of burnouts should occur early in life. The mortality curve of mercury lamps is not as steep as filament or fluorescent. This is another reason mercury lamps are not often group-relamped.

2. When *S*—spot-replacement labor cost per lamp—is high group relamping is particularly economical. Filament-lamp installations sometimes may have higher spot-replacement labor costs than fluorescent because of the fact that widely spaced industrial fixtures or recessed store-lighting fixtures may be harder to reach.

3. With *I*—group-relamping interval in terms of average lamp life—in the denominator, it means that all group-relamping costs are divided by a number smaller than one, or in other words the costs are increased. If the group-relamping interval is 80 per cent or 8/10 average life, this means that lamps will be replaced more often than in a spot replacement plan so that 10/8 or 25 per cent more lamps will be needed. Obviously, if the lamp costs are high, as with mercury lamps, the labor savings of group relamping will have to be high in order to offset the cost of the depreciated lamp that is thrown away.

ABNORMAL OPERATION

For most economical operation of a lighting system, the components of the system should be operated within their design limits. Costs can increase rapidly if such limits are exceeded.

1. *Operating the Lamps at Over- or Undervoltage.* Overvoltage or undervoltage operation of incandescent lamps has a pronounced effect on life and efficiency. For example, if a lamp rated at 115 volts is operated at 120 volts, its life is reduced about 50 per cent (light increased 15 per cent); if it is operated at 110 volts, its life is increased 70 per cent but its efficiency is reduced 15 per cent. Fluorescent and mercury lamps are less sensitive to abnormal voltages. Generally, a fluctuation of ± 10 per cent in line voltage for fluorescent and ± 5 per cent for mercury will have no appreciable effect on the life or efficiency of these lamps. Beyond these limits, however, whether it be 10 per cent too high or 10 per cent too low, reduced life is the result.

2. *End of Lamp Life.* In fluorescent installations where standard starters are used, the lamps will blink at the end of life. By replacing the lamps promptly, the annoyance of blinking lamps is removed, starters have a much longer life, and ballasts are not overheated.

High currents may occur at end of life with slimline or other instant start lamps. Therefore, it would be advantageous to install a group-relamping program to replace most of the lamps before they burn out.

3. *Defective Starters.* If a starter is defective or near the end of life, shortened lamp life can result. A short-circuited starter causes the ends of the lamps to glow because there is continuous current through the cathodes. This results in short lamp life. Erratic starting caused by a starter near the end of life also can result in reduced lamp life. In all such cases, the starter should be replaced promptly.

CONCLUSION

To reduce the costs of any lighting system, the relative importance of each cost in the system should be recognized. This knowledge will enable a direct and organized approach to cost reductions.

Maintenance costs can be reduced by the simple procedure of using practical and efficient maintenance methods and by allowing the lighting system components to operate under the conditions for which they were designed.

Largest Circuit Breaker Shipped

Three tanks of the world's largest circuit breaker, built by the General Electric Company, Philadelphia, Pa., are loaded on two railroad flat cars prior to being shipped recently to the Philip Sporn generating station of the American Gas and Electric System, New Haven, W. Va.

Impulse Ionization and Breakdown

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A PHOTOGRAPHIC TECHNIQUE was used to measure ionization under impulse voltages in transformer mineral oil and in transformer Askarel (a chlorohydrocarbon). Two electric-field conditions were investigated.

In the first condition, the liquid under test surrounded disk electrodes between which were placed impregnated pressboard and photographic paper. One electrode was round edged, the other square edged, a configuration found by Dakin and Works[1] to yield polarity effects in impulse-breakdown tests on Askarel-impregnated pressboard. Standard $1^1/_2$x40-microsecond impulse-voltage waves were applied to the electrodes, the reported polarity being that of the round-edged electrode facing the photopaper.

Impulse ionization was detected at a threshold voltage which was 42 per cent of the pressboard breakdown voltage for mineral-oil immersant and impregnant. As the voltage was raised, the ionization patterns became defined more clearly and increased in radius, similar to Lichtenberg figures in air. Photographs with an external camera show that the ionization in the liquid emits light.

The patterns for mineral-oil immersant in the upper portion of Fig. 1 show that the pattern characteristics and radius are independent of the polarity of the applied voltage. The breakdown voltage of the mineral-oil impregnated pressboard is also independent of polarity. Photopaper records of ionization in transformer-Askarel immersant are shown in the lower portion of Fig. 1. The positive-polarity figure indicates circumferential propagation of the ionization in Askarel rather than the nearly radial propagation for mineral oil. The negative-polarity figure exhibits restricted bushlike characteristics. In most cases, the ionization in Askarel originates in only one or two locations, and is of greater maximum density, compared with the more nearly uniform ionization in oil.

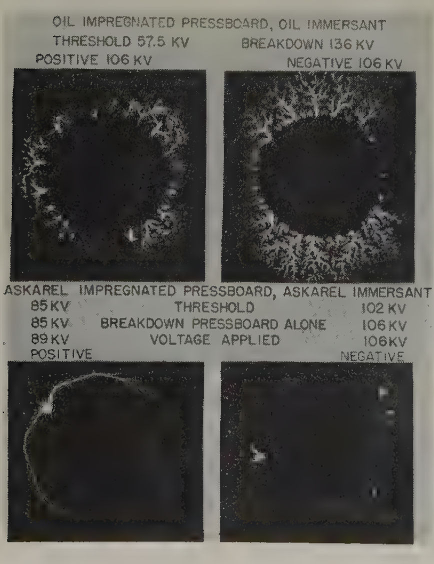

Fig. 1. Impulse-ionization patterns in liquid immersants, showing polarity effects

Threshold-ionization voltages for Askarel are substantially greater than those for mineral oil because of the higher dielectric constant of Askarel. With Askarel impregnant and immersant, the pressboard breakdown voltages are only slightly higher than the threshold voltages, and are much lower than the impulse-breakdown voltages for oil-impregnated pressboard. For Askarel, the positive-polarity threshold voltage and the pressboard breakdown voltage are lower than the negative-polarity values.

The propagation velocities of ionization streamers were investigated by chopped-impulse-wave tests. For oil immersant, the ionization branches grow in the time range, 2 to 30 microseconds. Once the positive streamer starts in transformer Askarel, it propagates through adjacent highly stressed regions at a velocity which may reach many centimeters per microsecond. This may explain the relatively low impulse breakdown strength of Askarel-impregnated pressboard when ionization occurs in contact with it. Lateral propagation of the positive streamer through highly stressed Askarel in the pressboard capillaries is possible in a few microseconds.

In the second test condition, the pressboard was replaced by a polystyrene sheet and the upper electrode was raised above the sheet to permit the liquid to fill the intervening space. Both electrodes were round edged. Test results indicated that the field in the liquid layer was virtually uniform. Ionization in transformer oil was investigated with photopaper over and under the polystyrene barrier for oil-layer thicknesses of $^1/_{32}$ inch to $^1/_8$ inch.

For the thicker oil layers, ionization was detected prior to barrier breakdown with negative-polarity voltages. For the thinner oil layers, more than one ionization nucleus was observed at both polarities.

The threshold impulse-ionization stresses measured with photopaper under the polystyrene barrier agreed with values obtained with the photopaper above the barrier (in contact with the oil). Threshold stresses increased from 300 to 600 kv per cm as oil-layer thicknesses decreased from $^1/_8$ inch to $^1/_{32}$ inch. Extrapolated values for thin films agree with the 800 kv per cm values computed from the pressboard-in-oil tests. Impulse-breakdown stresses for the oil alone (without the barrier) were usually a little higher than the threshold-ionization stresses.

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The experimental work was performed in the High-Voltage Laboratory of Northwestern University.

Mechanism of Impulse Corona and Breakdown in Oil

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OIL IS USED widely in electric apparatus as an insulating medium. Past investigations on the breakdown mechanisms of oil insulation generally were restricted to uniform field conditions and slow varying voltages. However, electric apparatus frequently contain some nonuniform fields and often have to pass impulse acceptance tests.

A 3-inch point-to-plane gap configuration was used since it produces a divergent field. In addition, its breakdown characteristics are likely to be similar to that of a quasi-uniform field gap or a gap with long creepage path if it is recognized that the first breakdown streamer distorts the field of the gap, giving it a nonuniform characteristic. Positive and negative 1.5×40-microsecond impulse waves, standard for impulse testing, were applied to the gap at 190 kv and 240 kv respectively. These voltages were slightly higher than the critical breakdown voltage of the 3-inch gap. For most tests, an insulating barrier was laid on the ground plane to limit the breakdown light intensities for photographic studies. Since the breakdown started at the point, a barrier on the ground plane had no effect whatsoever on the breakdown mechanism until the streamer bridged the gap.

In order to study several aspects of the breakdown mechanism at once, data were obtained simultaneously with a high-speed moving film camera, still cameras, photocells, and current-measuring devices. A set of typical photographs for each positive and negative streamer propagation and their associated current and light oscillograms are shown in Fig. 1*A* and Fig. 1*B*. The photographs and oscillograms had to be touched up slightly to emphasize details that would have been lost in the printing process. The breakdown phenomenon can be divided into four parts for either polarity; namely, initiating streamer from the point, successive streamer propagation in the oil, gap bridged by streamers extending from point-to-barrier surface, and restrikes. The mechanism of the negative point-to-plane in oil shows a remarkable similarity to that of natural lightning to open terrain. However, the former is on a miniature scale. The over-all velocity of oil streamer propagation is about 0.3 cm per microsecond, some 50 times slower than the downward lightning stroke.

The observed channel diameters of oil streamers at various stages ranged from 10 to 50 mils. On a statistical basis, the maximum intensity of light emitted from an oil streamer appears to be linearly proportional to the streamer current measured in the electric circuit. As seen from the photographs, a considerable difference in channel diameters and light intensities for the two polarities exists.

The Lichtenberg figure produced by an oil streamer impinging upon a barrier might be used as a measure of the barrier voltage by comparing the figure with that produced by a point electrode placed against the barrier.

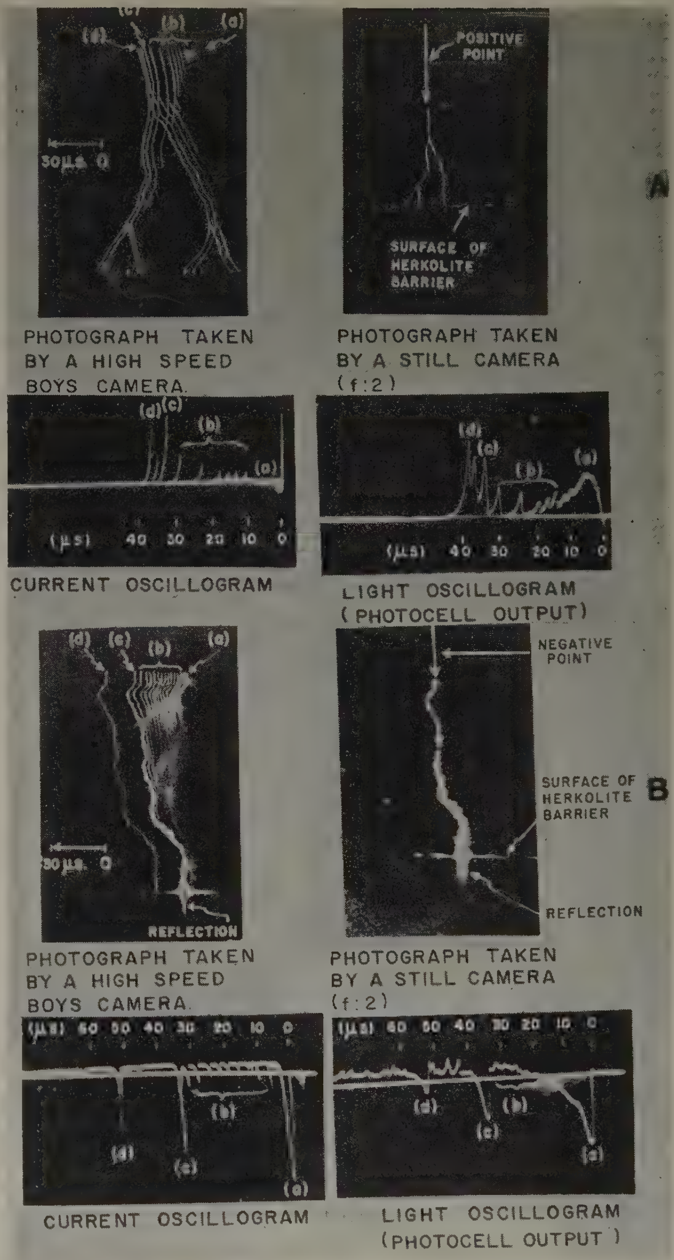

Fig. 1. Photographs and oscillograms showing the mechanism of 1.5×40-microsecond impulse breakdown of a 3-inch point-to-plane gap in 10-C oil (3/8-inch-thick Herkolite barrier on plane)

(*A*) *Positive point-to-plane gap;* (*B*) *Negative point-to-plane gap* (*a*) *Initiating streamer;* (*b*) *Successive streamer propagation;* (*c*) *Gap bridged;* (*d*) *Restrike*

Digest of paper 53-280, "Propagation Mechanism of Impulse Corona and Breakdown in Oil," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Published in AIEE *Communication and Electronics*, November 1953, pp. 641–8.

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Test Results of an Inner-Cooled Generator

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The specific electrical tests conducted are discussed together with the results obtained. These shop tests, which agreed closely with the calculated performance, demonstrated the practicability of applying the improved cooling technique to large turbine generators.

THE FIRST unit constructed to realize high specific output capacity by means of inner-cooling was an 0.8 power factor (pf) generator base rated at 80,000 kw at 30 pounds per square inch gauge (psig) hydrogen pressure, and having a capability of 100,000 kw at 45 psig.* It was designed around a rotor weighing 50 per cent as much as a conventional unit of the same rating and it had an over-all weight approximately 75 per cent as great as for a conventional unit. Results of an exhaustive series of tests made to verify the calculated performance are reported.

ELECTRICAL TESTS

WHILE a series of electrical and mechanical tests were conducted at various pressures up to 96 psig, only 30- and 45-psig tests are reported. Electrical tests were made for the open-circuit and short-circuit conditions and for zero power factor loads at controlled voltages for both leading and lagging conditions.

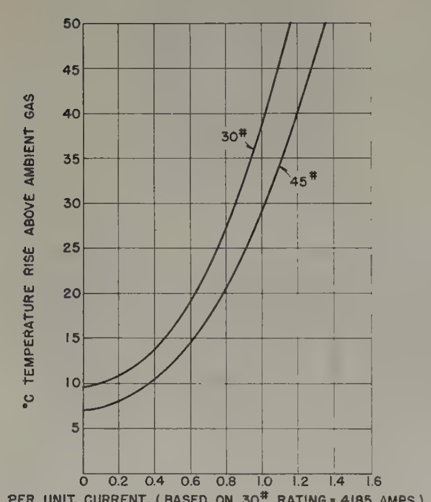


Fig. 1. Temperature rise as determined by the maximum rise of resistance-type detector between coil sides in the slot portion of the generator

To determine merit, many more measurements were made than would be the case for a conventional machine. In addition to the conventional resistance-type detectors between coil sides in the slot portion of the windings, thermocouples were employed to measure temperatures of the bare copper at various points along the length including the hot-spot region at the end of the coils. Special detectors also measured the temperatures of the cooling tubes in the coils. Supplementing the usual core temperatures, the stator teeth, magnetic end shield, finger plate, and building bar temperatures were measured. The rotor mean copper temperature was obtained by observing the change in conductor resistance.

TEST RESULTS

The temperature rise of the hottest resistance-type detector located between coil sides of the stator winding near the turbine end of the generator is shown in Fig. 1. While not presumed to be the most significant measurements, determined at least 80 inches from the hot spot copper, and not even measuring actual copper temperatures locally, they are reported for comparing to the hot-spot copper rise.

A plot of the multiplier for the hot-spot copper temperature rise relative to the rise of the embedded detector is shown in Fig. 2. Hot-spot temperature detectors were located in the coils nearest to the neutral and the leads were carried within the coil insulation to the solidly grounded neutral. While safe for measurements during test, the neutral is not solidly grounded in service and the detector leads had to be removed for reasons of safety.

To obtain the hot-spot temperature in service, determine the per unit current, the maximum resistance-type detector rise, and the multiplying factor from Fig. 2 for the appropriate hydrogen pressure. The product of the last two figures gives the hot-spot copper rise to be added to the ambient.

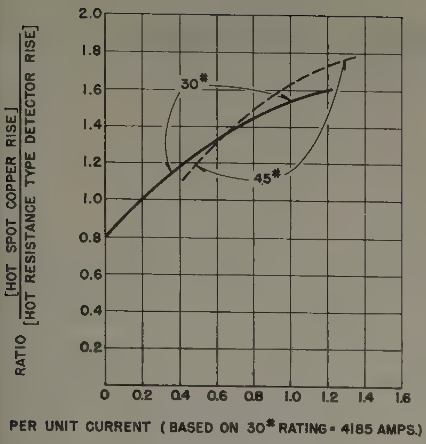
The current-carrying capacity of the stator as a function of pressure is given in Fig. 3; it is that current required to give 85 C rise above a 45 C ambient. Despite some insulation between the copper and the vent tube, the capacity continues to rise significantly with pressure even in the neighborhood of 100-psig hydrogen pressure.

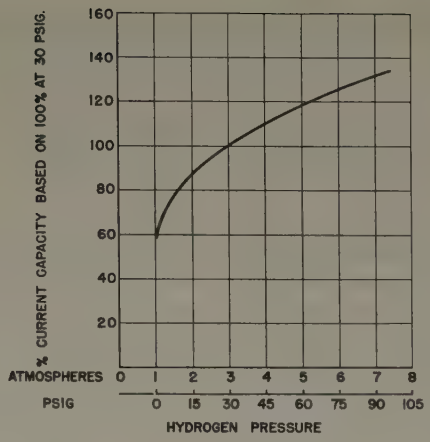
Fig. 4 shows the current-carrying capacity of the rotor, or that current giving 51 C mean temperature rise (mean gas rise plus gradient between copper and gas) since calculations showed the mean rise to be 60 per cent of the maximum or hot-spot rise (total gas rise plus the afore-

* "Ventilation of Inner-Cooled Generators" by R. A. Baudry and P. R. Heller, a condensed version of AIEE Technical Paper 54-50, was published in *Electrical Engineering*, June 1954, pages 508–13.

Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, and recommended for publication by the AIEE Committee on Rotating Machinery.

W. C. Brenner and **P. R. Heller** are both affiliated with the Westinghouse Electric Corporation, East Pittsburgh, Pa.





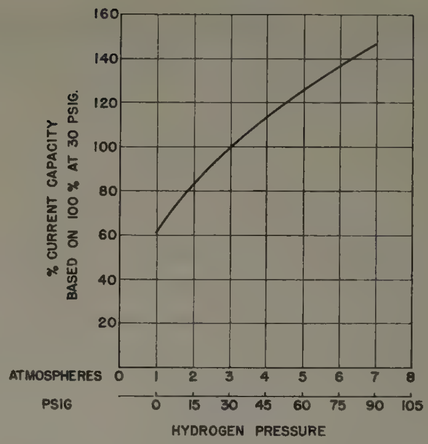
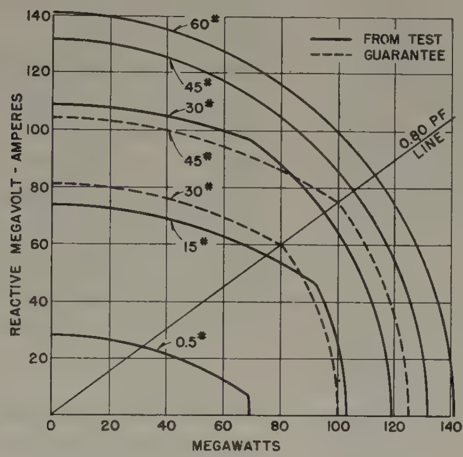
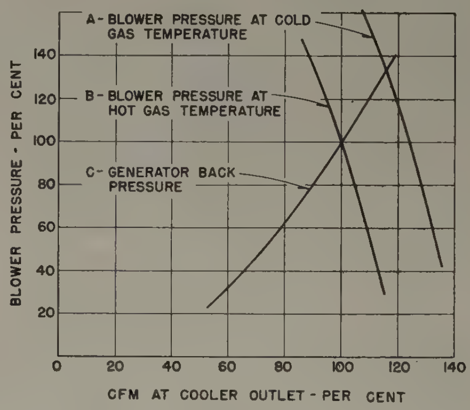


Fig. 2 (left). Ratio of the hot-spot copper rise and the rise of the hottest detector between coil sides as a function of the stator current for both 30 and 45 psig cases. Fig. 3 (center). Maximum stator current as a function of hydrogen pressure for the condition of maximum hot-spot temperatures. Fig. 4 (right). Maximum rotor current as a function of hydrogen pressure for the condition of maximum hot-spot temperatures

Fig. 5 (left). Capability curve of inner-cooled generator: 80,000 mw at 30 psig; 100,000 mw at 45 psig; 0.80 scr; 0.80 pf; hydrogen pressure expressed in psig; pressure is the variable parameter. Fig. 6 (right). Performance of 3-stage axial blower





mentioned gradient) which was assumed could be a temperature of 85 C.

Both the guaranteed and test capabilities are given in Fig. 5. The extraordinary test margin is not typical as the developmental unit was applied to a current order for a conventional unit. Note that the break in the curves denoting the shift from stator-limited capability (right-hand portion) to rotor-limited capability (top portion) disappears at 45 psig and above indicating the entire kilovolt-ampere capability for all overexcited power factors.

The pressure volume characteristics of a duplicate blower tested in a rig simulating the generator ventilation system are shown in Fig. 6. Curve *A* is the characteristic for cold gas as it leaves the coolers. Curve *B* is for hot gas (lowest density gas corresponding to the maximum load conditions) and gives pressure as a function of the volume of cool gas leaving the cooler. The minimum pressure required to produce the desired flow is designated as 100 per cent in the curve.

The generator reactances tested close to the calculated values. The synchronous reactance was nearly the same as for conventional units, since a specified short-circuit ratio (scr) required lengthening the air gap proportionately to the specific output in terms of high-ampere conductors per inch of periphery of the air gap. The subtransient reactance was almost doubled, since its value is intimately connected with the geometry of the unit and is relatively insensitive to air-gap changes. Initial short-circuit currents for inner-cooled generators will be low on a per-unit basis or rather the short-circuit kva will be equal in magnitude to that of a conventionally rated unit of the same physical size. The transient reactance is higher than it is for many conventional units, though it is not quite doubled.

The reactance values, while not having the same relative magnitudes as for a conventional unit, fall in an entirely satisfactory range.

The shop tests, closely agreeing with the calculated performance, demonstrated the practicability of applying the improved cooling technique to large turbine generators. Confidence in the use of inner-cooling for 250,000-kw generators now on order has been strengthened and it is believed that the demand for inner-cooling, therefore, will continue not only in numbers, but for even higher ratings.

New 12-Channel Open-Wire Carrier System

A. G. EWING F. W. FRAZEE DALE WELLING

THE *45A* 12-channel carrier system for open-wire lines is the first of a new line of carrier equipment known as the *45* class, developed for application on open-wire lines, paired and coaxial cable, and radio systems. Both electrical and mechanical design have been co-ordinated for each of the systems, and basic terminal equipment is identical for the various applications. Great stress has been placed on standardization, both to speed the development in the different areas of ultimate use, and also to increase the demand for specific items of manufacture.

The equipment is miniaturized to a very high degree and makes extensive use of plug-in unit arrangements. To attain a maximum of uniformity, these various plug-in units make use of a number of plug-in subassemblies to provide needed differences. In contrast to former arrangements for 12-channel terminals including accessories which occupied several bays of equipment, the miniaturized *45A* system occupies a fraction of a single relay rack.

Type *45A* systems come complete from the factory with field installation requiring only the connection of speech and signal drop leads, high-frequency line, and power supply to the terminal block.

A shelf assembly for a 12-channel terminal consists of five sections or rows of equipment, largely of a plug-in type, occupying only $31^1/_2$ inches of vertical rack space. The bottom three sections of plug-in units are identical, each consisting of four channel units and one pregroup or combining unit. Each plug-in unit in these three sections is a rectangular box assembly $3^1/_4$ inches wide, $6^3/_8$ inches high, and 10 inches in depth. Each has a 20-pin multicontact plug mounted at its rear through which all transmission and power connections are carried.

Plug-in units in the top two sections include carrier supplies for the channel and group equipment throughout the bay, group modulating and other common equipment in the transmission circuits, and alarm equipment. Certain of these units are broken down further into plug-in subassemblies either for test purposes or to standardize arrangements provided at repeaters and East and West terminals.

The channel unit is typical of the mechanical construction of all *45*-class equipment. This unit is shown in Fig. 1 with all of the plug-in subassemblies removed. The band filters and voice-frequency low-pass filter are in the large rectangular cans at the left. Two versions of band filters and two versions of voice filters are provided. One set provides a channel bandwidth from 250 to 3,100 cycles; the other provides a bandwidth of 200 to 3,400 cycles. Other plug-in subassemblies include a relay, a resistance hybrid, and a plug-in signal unit. The basic chassis includes resistance card assemblies and modulator-demodulator units.

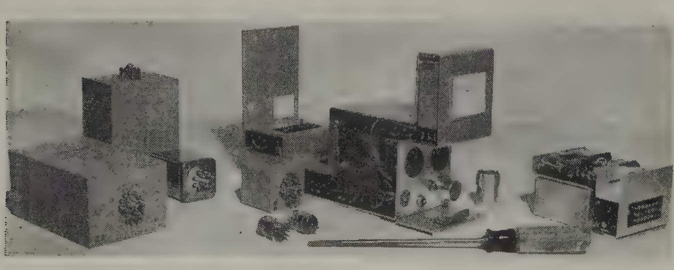


Fig. 1. Channel unit with all plug-in subassemblies removed

Accessory equipment for *45A* systems includes ringdown converter units, a-c power supply, line filters, 4-wire terminating sets, and other units which are miniaturized in the same manner as the terminal equipment, wherever possible.

Filters for *45*-class systems are considerably more compact than in previous systems. Typical of these is the channel band assembly. Both transmitting and receiving filters are in a hermetically sealed can with an 11-pin vacuum tube base plug. Permalloy coil tuned meshes are used with cores of about 3/4 inch diameter. Mesh tuning in these filters takes advantage of the fact that no extremely great accuracy is required because all frequencies lie below 24 kc. With a few categories of precision-wound coils and precision-wound polystyrene capacitors, precision tuning of individual meshes is not required.

Development of *45*-class equipment required a complete new line of transformers. It has been possible to obtain the transmission performance required with laminated cores. Multiwound paper-insulated transformer winding was used with interleaved laminations throughout. Electrostatic shields were found unnecessary in most cases because of the small size of the transformers.

Along with great stress on miniaturization, much emphasis has been put on use of good sealing components against humidity, better fungus protection for tropical use, longer life vacuum tubes, and more stable and precise resistances.

It is believed that *45*-class equipment is well adapted to present-day needs in application of carrier equipment. More and more, carrier is spreading to remote offices where maintenance is frequently a problem. Extensive use of plug-in assemblies, easily removed and sent to centrally located repair centers, is becoming a necessity. With *45*-class equipment, simple bridging tests can determine inoperative assemblies, and with only a small stock of spare assemblies at terminal locations, reliable service can be maintained.

Digest of paper 54-102, "Mechanical Aspects and Component Features of a New 12-Channel Open-Wire Carrier System," recommended by the AIEE Committee on Wire Communication Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., Janaury 18–22, 1954. Published in AIEE *Communication and Electronics*, March 1954, pp. 75–81.

A. G. Ewing, F. W. Frazee, and **Dale Welling** are with Lenkurt Electric Company, San Carlos, Calif.

Automatic Inventory System for Air Travel Reservations

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E. L. SCHMIDT

An automatic system for handling air travel reservations through the combination of a magnetic pulse storage drum and electronic digital computer equipment is described here. During 1953 the central equipment operated 99.8 per cent of the scheduled time. This reliability points to wider use of such equipment in commercial and military applications.

A RUNNING inventory count of the available passenger accommodations on all scheduled American Airlines flights out of New York City area for 10 days in advance is maintained automatically, utilizing a rotating drum with a magnetic coating as the data storage unit, see Fig. 1. This central inventory of passenger flight traffic data is available, on a 24-hour basis and with a very low access or reply back time, through wire communication circuits to more than 200 reservations and ticket sales agents at La Guardia Airport and at remote locations. These agents, by operation of special adding machine type of keysets, see Fig. 2, interrogate the central inventory as to the availability of the desired number of seats on any particular flight or group of flights, they sell space, thereby automatically substracting from the inventory, and with limitations they make cancellations with consequent additions to the inventory count.

GROUP SELECTION OF INVENTORY DATA

BASICALLY the inventory data are stored in the form of seven digit binary numbers representing, up to 127, the current count of uncommitted seat space for each leg of each flight, a leg designating an individual portion of a flight between take-off and landing. A maximum of 1,000 leg inventory counts are stored in seven parallel recording channels or circumferential tracks around the drum for each of 10 days, the total capacity with 70 channels being 10,000 leg inventories. The leg address or interrogation code for these 10,000 units of storage is based therefore on first selecting inventory channels for the day, by connecting through relay contacts, seven out of 70 channels, and subsequently counting around the periphery of the drum by electronic counters to the desired one out of 1,000 leg inventories.

While it is quite practical for the agents to select the day of the month directly by operation of two date push buttons on the keysets, it is considered neither practical nor desirable for the agent operators to select individually from a possible 1,000 leg address codes, particularly since binary codes and counters rather than decimal are preferred from the standpoint of equipment simplification. Aside from the excessive time which would be required individually to check each leg of multiple stop flights, the serious difficulties of indexing and transcribing correctly a large number of flight and leg address codes dictated a system based on group selection of leg inventories with a minimum of keyset

Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953, and recommended for publication by the AIEE Committee on Computing Devices.

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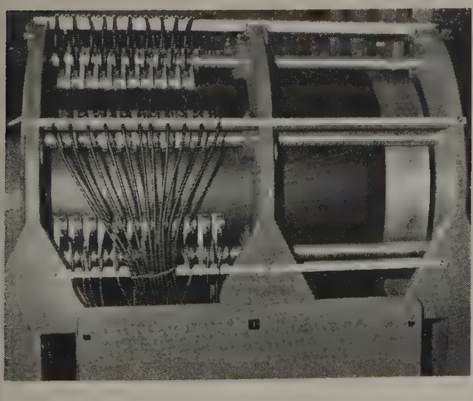
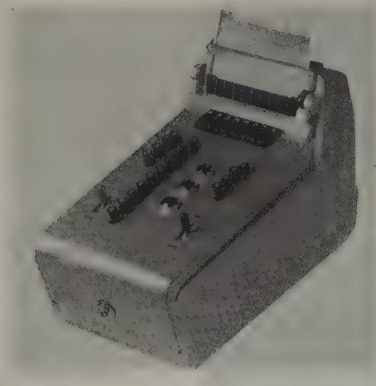




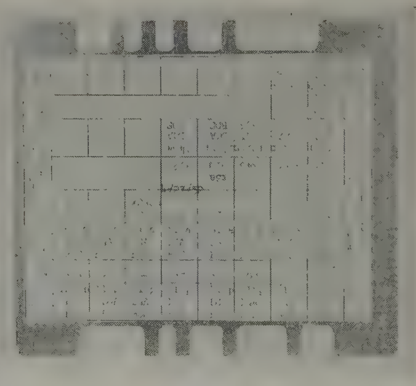


Fig. 1 (left). Magnetic pulse storage drum: Read-record heads for 112 channels equipped with space at right for future additions Coaxial leads from heads extend to channel selector relays mounted under the drum. Fig. 2 (center). Agent's keyset: Notched coded destination plate is inserted at the top for flight leg group selection. Movable shutter exposes one of two rows of timetable information and alters group selection coding. Locking keys are provided for date and number of seats. Fig. 3 (right). Destination plate: Printed label shows timetable information for flight legs associated in groups. Eight groups of eight legs each may be coded and designated on one plate, top and bottom, front and back

operations. The group selection scheme adopted provides an arrangement of from one to eight associated leg inventories which may be checked with one keyset operation, and involves the use of a notched disk called a destination plate, see Fig. 3, which is inserted into a slot on the keyset as described hereinafter. Each plate provides code notches and corresponding printed designations for eight flight leg groups. This grouping of leg address codes is a flexible programming feature of the system and is accomplished manually using a "Master" keyset, by writing into a separate program section of the storage drum the individual leg address binary code numbers up to a maximum of eight which are semipermanently associated in a group. The binary coded input signals representing the group as transmitted automatically from the notched destination plate are translated and expanded by this means into a series of leg inventory selection addresses which control individual operations of checking each leg inventory automatically in time sequence. Individual leg addresses may appear in more than one group and hence operations may often be simplified by checking availability of space on more than one flight at a time.

FIXED PROGRAMMING

Semiautomatic programming features of the system, including mathematic operations of addition, subtraction, and comparison, also the magnetic read-record and error checking, are set up on a combination of electronic and relay circuits, with basic timing from the storage drum which revolves at approximately 1,170 rpm.

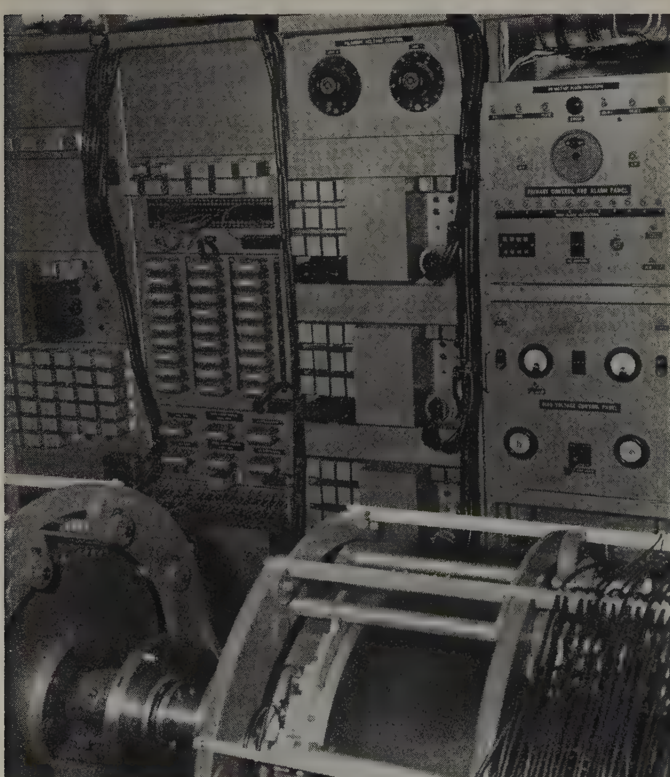


Fig. 4. Input-output switching and power control: Date decoding circuits and request call counters at left rear. Remote transceiver panel in center. M-G and filament voltage controls right. One of two duplicate storage drums in foreground

INPUT-OUTPUT CHANNELS

The multiple input-output communication channels connecting with the agent sets are picked up in sequence, on a time-sharing basis through seeker connector circuits with generally conventional automatic relay switching components, see Fig. 4, to which have been added special guard features operative in case of the occurrence of certain detectable errors in input signals. The input register is held connected to the calling agent's set until the answer back has been computed and transmitted by the central electronic equipment. The average reply back time is approximately 1 second, the maximum and minimum depending upon the type of operation requested; that is, "availability" check on one leg being the minimum and a "sale" or "cancel" on an 8-leg group requiring the maximum time. The peak capacity of this system is at present approximately 3,000 agent set operations per hour.

RELIABILITY AND ACCURACY

The disposition of the principal functional elements of the system is shown in Fig. 5 in schematic form.

The layout of this system as well as the selection and design of all circuits and components are heavily weighted for maximum reliability and continuity of error-free operation, as would be anticipated from the requirement for 24-hour service, while maintaining an accurate and dependable inventory count in the absence of other central and co-ordinated records of passenger space availability. This list includes the more important design features incorporated for prevention of interruptions to service and for detection of errors or potential equipment failures:

1. *System and Circuit Design:*

(*a*). Duplicate electronic and magnetic storage equipments held in continuous stand-by operating condition.
(*b*). Generous mechanical and electrical tolerance specifications including magnetic pulse packing factors, repetition rates, voltages, and pulse form factors.
(*c*). Twin contact relays as circuit switching elements rather than electronic devices wherever timing permits.
(*d*). Extraordinary care in shielding and filtering both signal and power leads.
(*e*). Limiting voltages of relay circuits to 50 volts direct current and electronic power supplies to ± 120 direct-current maximum.
(*f*). Elimination of direct current in magnetic recording heads to avoid the possibility of accidental alteration or wipe out of program or inventory.
(*g*). Heat dissipation limited and dispersed to avoid forced air ventilation without excessive hot spots.
(*h*). All circuits amply fused with audible and visual indicators.

2. *Maintenance Facilities:*

(*a*). Provision for marginal voltage operational test on entire electronic system, i.e., variation of plate and bias voltages by manipulation of field currents in motor-generator d-c power supplies.
(*b*). Error detection and indicating circuits, designed with a minimum of checking equipment, continuously

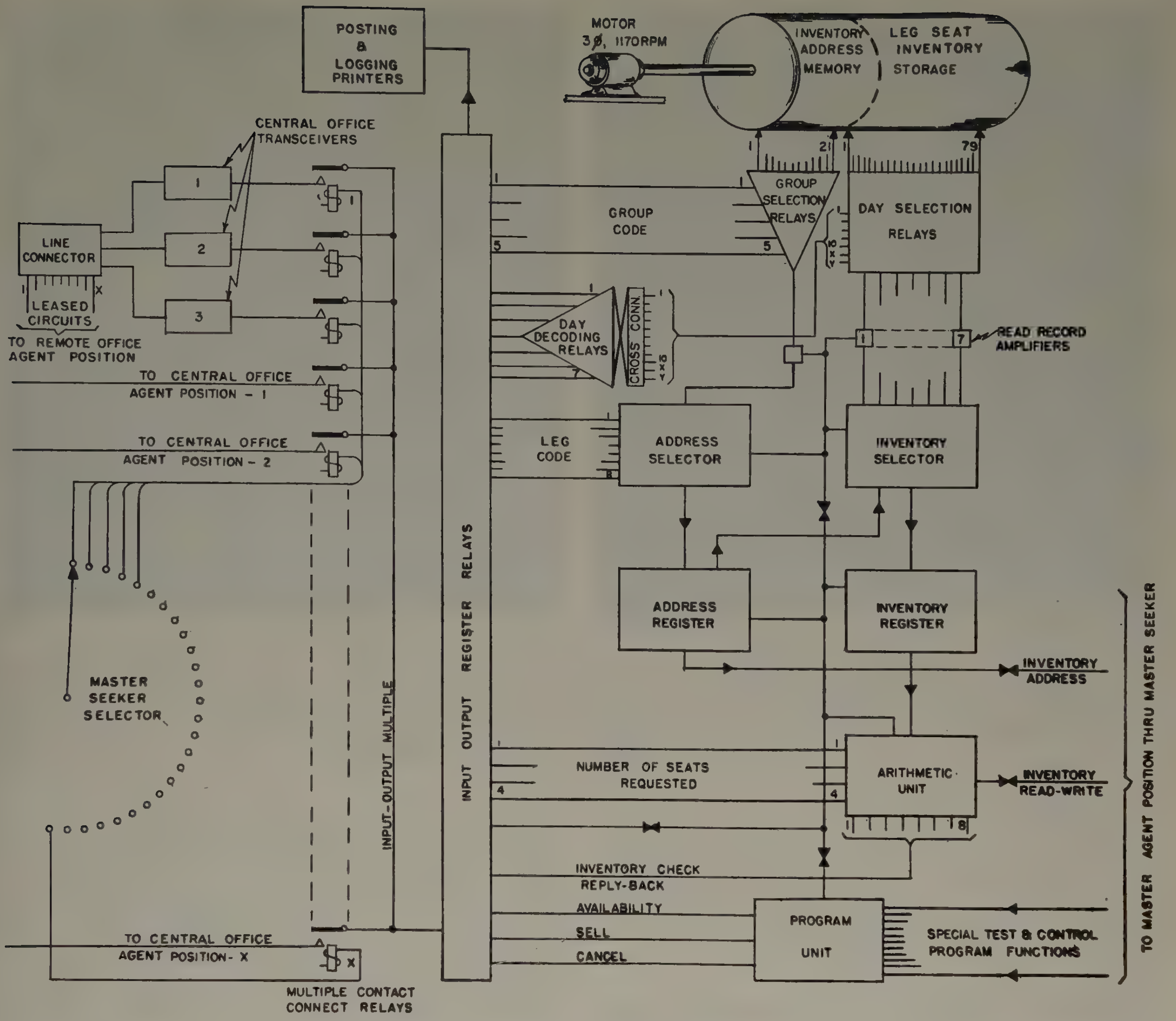


Fig. 5. Simplified system block diagram

monitoring the operation of electronic and magnetic recording and computing systems.

(*c*). Monitor printers (Teletypes) for automatically recording input and output signals whenever errors are indicated.

(*d*). All essential electronic components and relays mounted in plug-in assemblies, generally as functional units to facilitate replacement and bench testing, see Fig. 6. Keysets also equipped with plug-jack terminals.

(*e*). Centralized visual monitor and test panel for electronic system test operations.

(*f*). Rack wiring standardized with signal and power leads separated on double deck terminal boards, see Fig. 7. Power and signal interchassis connections through jacks.

(*g*). Tube types and basic electronic circuits standardized with minimum number of types of replaceable units.

(*h*). Spare inventory addresses maintained for test calls, i.e., check calls having known correct answers.

3. *Component Design:*

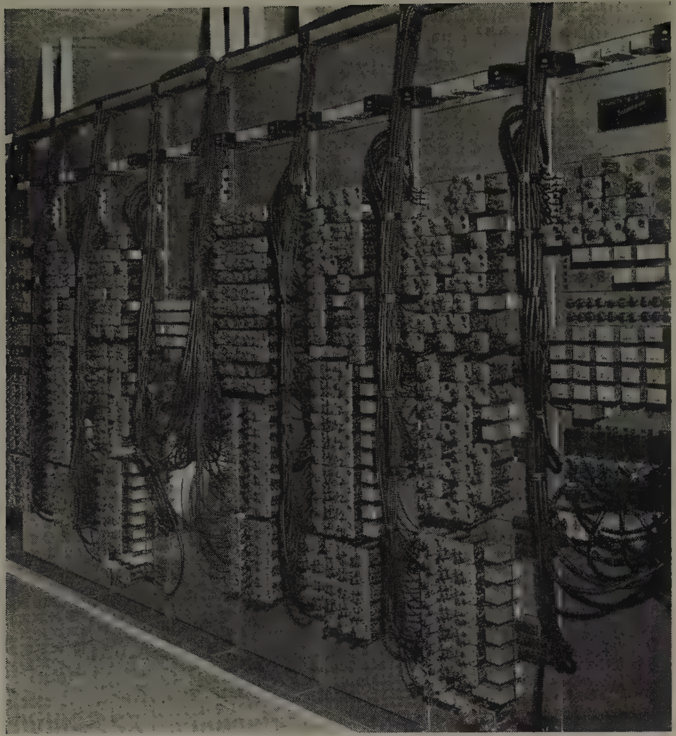
(*a*). All components, wire, and wiring devices of Joint Army-Navy approved standards or better.

(*b*). Dip-soldered etched copper connection boards on electronic subassemblies, see Fig. 8.

(*c*). Essential electronic tubes of proved long-life computer types.

To insure correctness and compatibility of circuit and component designs, a complete prototype system was set up in the laboratory and tested over a period of about 12 months, prior to installation of operational equipment. During this period a training schedule for a selected group of service personnel was organized, for theoretical instruction in pulse electronic circuits, system operation, and practical testing and adjustment of all components.

This system has now been in continuous operation for almost 2 years, with a very excellent service record. The



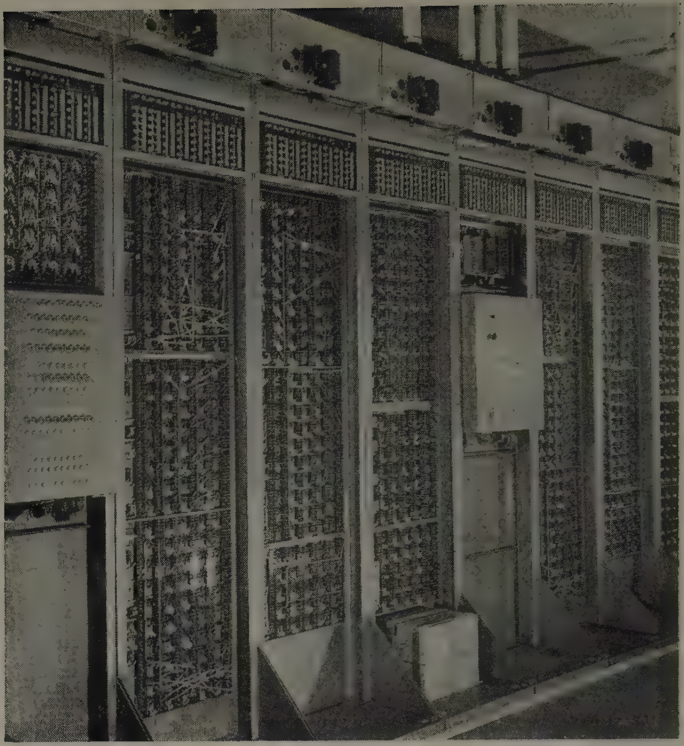


Fig. 6 (left). Main equipment racks in duplicate: All inter-rack electronic signal wiring is carried in coaxial cables, relay leads in unshielded cables. Power supply cables lead to each panel from supply at top of racks. One set of eight read-record amplifiers shown at top center. See Fig. 7 for rear construction of these racks. Fig. 7 (right). Main equipment racks: Rear view showing arrangement of double-decked power and signal wiring and test points with alarm-type fuses at top. Heater and plate supply terminal arrangement is completely standardized

functioning of the system to date indicates that the required degree of accuracy may be maintained continuously and indefinitely within the limits of normal maintenance procedures and costs. Undoubtedly, design improvements and more efficient maintenance procedure will be suggested by continued operational experience and new component developments in this field.

During the year 1953, the central equipment operated 99.8 per cent of its scheduled time. In 17,000 hours of service only 8 per cent of the two important type tubes were replaced. Daily routine maintenance and operational checks including insertion of new day's inventory is made during the 2-hour period commencing at midnight.

TECHNICAL DESIGN DATA

In each of two identical central computer and memory equipments there are 375 *396A* twin triodes, 309 *415A* pentodes, and 16 *6Y6* power amplifiers. There are 20 *5963* twin triodes used in monitor and test circuits.

The power supplies consist of dual output motor generators driven by 3-phase motors. The outputs are: +120 volts, 5 amperes, for plate and screen circuits and −120 volts, 3 amperes, bias. Both generators have field current dropping resistors for marginal voltage testing. Heater supply is 6.3 volts alternating current, induction regulated, with manual starting variacs.

Binary arithmetic is used throughout with no conversion to decimal. The parallel static electronic add-subtract units are relay programmed.

The magnetic drum storage unit is of horizontal cast aluminum construction with a 20-inch diameter and $27^1/_2$-inch axial length. Drum speed is 1,170 rpm giving an access time of approximately 50 milliseconds. The magnetic pulse recording is of the bipolar type; positive for binary *1*, negative for binary *0*. Approximately 20 pulses per inch are recorded in parallel tracks with an axial spacing of 8 per inch. The head is of the Harvard Computation Laboratory type, modified. The air gap, head pole to drum surface, a sprayed black oxide magnetic coating, is 0.002 inch.

Approximately 130 relays of the twin-contact plug-in type are used in each equipment. Relay operating voltage is 50 volts direct current from motor-generator set and, when operated from electronic circuits, two twin-triodes *396-A* are used as relay pullers.

Input-output communication equipment includes two 25-point rotary stepping switches as a line seeker unit with multitwin contact relays as line connectors.

Remote transmission channels are operated over a telephone pair utilizing serial polar pulses, sequenced at both ends by rotary stepping switches. Transceivers at both the remote location and at the central provide for utilization of the "local"-type multiconductor agent keyset with transmission over a single circuit.

NOVEL OPERATING FEATURES

Some of the more important features which have contributed to the practical operational efficiency of the system, other than adequate speeds and capacities, are listed in the following paragraphs, but a detailed discus-

sion of their relative merits and reasons for final adoption is beyond the scope of this presentation.

However, it may be stated that the arrangement and design of the functional components and the provisions for novel methods of operation built into this system were developed over a period of years jointly by American Airlines and Teleregister engineers and operating personnel. Valuable experience was provided by the results of operation of the experimental semiautomatic installation at the American Airlines' Boston, Mass., reservations central in service since 1945.

1. No manual encoding of flight numbers, code charts, or reference tables, other than the automatically coded and indexed destination plates previously mentioned, are required for operation of the agents keyset, see Fig. 2. The date is automatically decoded to select the storage drum channels for the proper one out of 10 days (plus *X* and *Y* days) by means of a relay bank and cross-connection plugboard at the central (upper left of Fig. 4).

2. Locking type of buttons are used for agents' keysets, which allow a visual check of selected date and number of seats before initiation of transmission to the central equipment.

3. The quantitative inventory of unallocated seats maintained in the storage drum is not available to reservation clerks or ticket sales agents. The reply back is positive and visual yes-no signals in response to the interrogations involving a specific number of seats, on a particular group of flight legs for a specified date. The exact seat count balances, however, may be read out of inventory storage in binary numbers at master agent set positions.

4. A Teletype printer is provided to record a sold-out condition whenever the inventory count on any leg of any flight is reduced to zero. An agent may not complete a cancellation into a sold out leg or flight, but is given a REJECT reply signal which requires that such cancellations be referred to the Wait List clerk by separate phone communications.

5. In addition to the normal 10-day advance inventory memory, abbreviated storage channels are provided on the drum for 2 additional days, designated *X* and *Y*, which are reserved for assignment to special flight groups such as advance holiday reservations. A third special group of day storage channels, designated "advance day transfer," is available for manual setting up in advance and checking of seat inventories at master agents' positions. From this advance day recording (semipermanent) the expiring day's inventory is replaced, ordinarily at 0001 hour each day, by automatic pulse transfer operations to set up the new (10th) day inventory pattern.

6. It has been mentioned previously that a flexible programming or grouping of flight leg inventories is used. The present capacity of the system is 370 such groups (for each day), each group being composed at the master agent's set position by writing into the programming channels of the drum, up to a maximum of eight addresses. It should be noted that an important feature is the ability to associate individual leg addresses with more than one group. Drum storage capacity has been provided to allow for a considerable expansion in the number of flight groups and leg inventories by equipping additional channels with read-record heads.

7. When it becomes necessary to take out of service one of the two central electronic equipments for changes, repairs, or replacement of components, the lapsed inventory counts in the out-of-service drum may be restored to current values by rewriting from the other or in-service equipment through direct transfer of recorded pulses.

8. The central computing equipment returns an ERROR indication to the agents in case certain unintelligible or incomplete transmissions are received; for example, if the operator fails to depress one or both of the two date keys. In case of machine errors at the central, the same ERROR indication is returned to the agent and in addition all agents are locked out pending the printing of the ERROR record and release of the system to normal operations by the attendant.

MAGNETIC PULSE READ-RECORD CIRCUITS

The magnetic read-record head comprises a single winding on a laminated mu-metal core with a transverse air gap which is mounted approximately 0.002 inch from the surface of the rotating drum. A binary *1* is recorded by a "positive" current pulse in the winding of sufficient amplitude and duration to saturate a spot of the magnetic coating in the immediate area of the head at the instant of occurrence of the pulse. Such magnetic pulses are never erased from the drum in normal operation. The binary *1* magnetic recordings are completely eradicated and binary *0*'s of opposite polarity recorded by equal and opposite or "negative" saturating current pulses occurring in exactly the same time relationship to the rotation of the drum.

The read-record circuit schematic, see Fig. 9, indicates the arrangement of electronic components to generate in timed sequence, equal and opposite positive and negative current pulses of controlled shape and of 8-microsecond duration.

The record circuit has two inputs. The first input consists of a series of timing pulses at the rate of 20,000 per second which are shaped by a multivibrator type of circuit to produce a series of recording pulses of constant

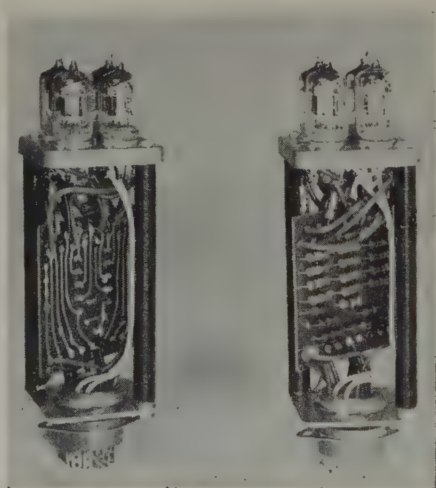


Fig. 8. Electronic plug-in subassembly: Principal components are mounted on dipped soldered etched circuit boards for uniformity and open construction. JAN-approved components and sockets are standard

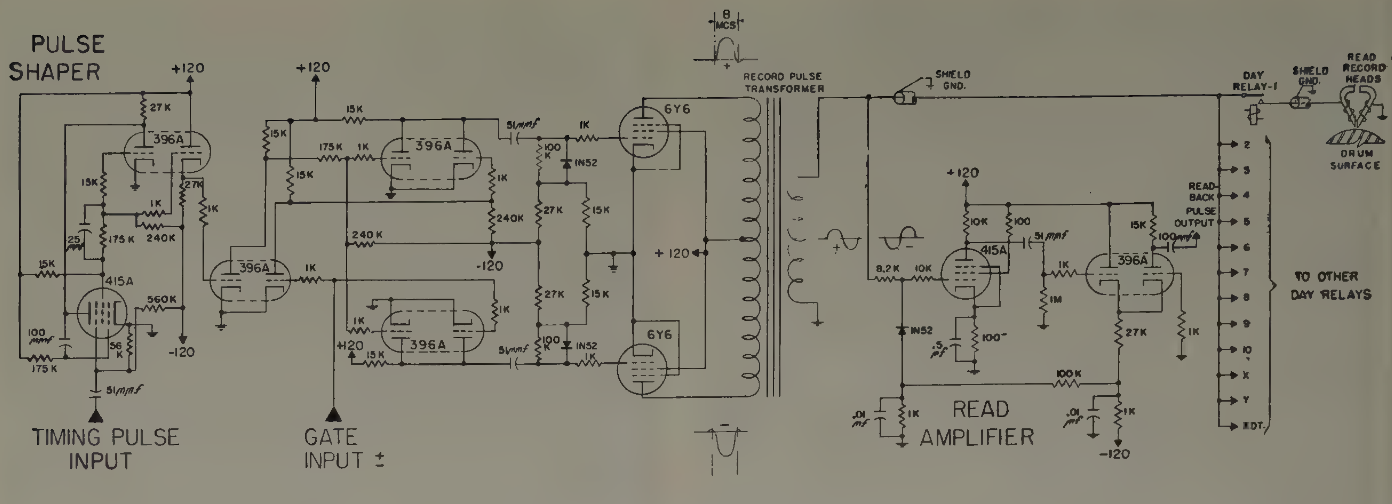


Fig. 9. Read-record amplifier schematic

length and shape but without polarity. The second recording input is the binary arithmetic series of positive or negative gating pulses which are used to admit the recording pulses from the shaper selectively to either one of two *6Y6* power amplifiers, having opposed primary windings of a pulse transformer in their plate circuits. The polarized pulse secondary output of the transformer is connected selectively through the contact of one of the day relays to the read-record head windings. Considerable care has been exercised both in the design of the circuit and of the pulse transformer to obtain balanced dynamic pulse characteristics.

Read-back voltage pulses are generated from the motion of the polarized magnetic spots past the air gap in the common read-record head winding and are transmitted through coaxial cables and the contact of the single day relay to the grid circuit of a high-gain pentode. This grid circuit is protected against the comparatively high positive recording potentials in the same circuit by a diode limiter. The second and third stages of the read-back amplifier consist of a triode and a grounded grid triode as shown in Fig. 9. Subsequent stages not shown include conventional clipping and gating features.

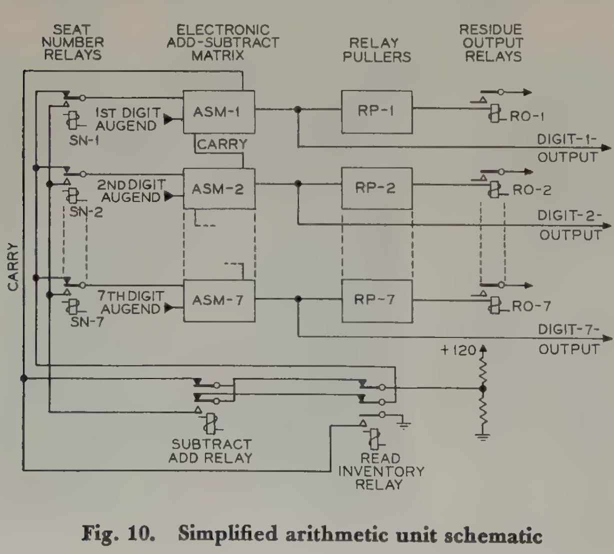


Fig. 10. Simplified arithmetic unit schematic

This read-record circuit has been found to produce uniform positive and negative read-back signals with a minimum of cumulative magnetic noise pick-up and with a minimum of switching and gating elements.

ARITHMETIC UNIT

The arithmetic or add-subtract circuits are of the three input binary parallel static electronic type. The residual digit totals appear as high or low voltages corresponding to binary *1*'s and *0*'s at the output terminals immediately the inputs are energized. Fig. 10 shows schematically the arrangement of three of the seven binary stages of the arithmetic unit, the other four similar stages being omitted for simplicity. The augend input from drum storage inventory is taken from electronic registers and the addend representing number of seats requested is from relay contacts. Input-output switching by prepositioned relay contacts establishes the program function to be performed, that is, subtract seats from inventory count for sell calls or add to inventory count for cancel calls. Subtraction is by the process of adding complementary binary digits with an initial carry to the first digit.

CONCLUSIONS

The combination of magnetic pulse storage drum and electronic digital computer techniques with communication nets connecting multiple local and remote input-output stations as developed for the Airlines Reservisor has a large potential field of commercial and military applications. Such applications, generally for very specialized uses, require careful systems study and analysis not only to meet requirements of capacity speed and accuracy but to provide, as well, those refinements of design which promote simple operating practices and workable test and maintenance routines. Indoctrination and training of operating and maintenance personnel must be completed well in advance of operational use.

With better understanding of the problems involved and co-ordinated programs of development with users, design engineers, and manufacturers, large high-speed centralized data storage and computing systems may now be successfully installed for continuous operational uses.

Sampled-Data Control System Transient Analysis

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IN MOST PRACTICAL situations involving sampled-data control systems, the designer has found it expedient to resort to analogue computer studies in order to determine how the transient response depends upon such factors as the sampling frequency or the velocity constant of the proposed system. The purpose of this article is to furnish a set of dimensionless curves, based upon computer studies, which are of a sufficiently generalized nature to permit approximate design criteria to be established for a wide variety of system transfer functions.

Fig. 1 shows, in basic form, the feedback-control system of interest. $G(s)$ represents the parts of the system described by conventional linear transfer functions, together with such time delay as would arise from a digitally computed source of error. The sampler simulates the portion of the system responsible for the sampling process, including a clamp-type hold circuit which is normally employed in sampled-data systems.

It can be shown that a system having an open-loop transfer function defined by

$$G(s)=\frac{K_v}{s(\tau s+1)^n} \qquad (1)$$

can be used to approximate the transient response of any control system of the linear, type *1* variety that has not been partially equalized by lag-network compensation. Since the system defined by the transfer function in equation 1 is to approximate the actual system of interest, it will be referred to as a pseudo system. In any particular problem, the pseudo-system transfer function is specified by selecting the appropriate values for τ and n in equation 1 so that the two systems have nearly equal open-loop transient responses. If two systems have nearly equal open-loop responses, their closed-loop responses will be similar regardless of whether the error is supplied continuously or in sampled-data form.

The following procedure should be followed in order to analyze the effects of various sampling rates on a control system under consideration. Select a pseudo system that has approximately the same open-loop transient response as the control system under consideration. It can be shown that the real-part plot of a given transfer function completely specifies the transient response. The appropriate pseudo system can be considered as one that best matches the real-part plot of the actual system. In order to relate the real part plot to the time response, the poles of the system transfer function must lie in the left-half s plane. Since $G(s)$ contains a pole at $s = 0$, the real part of $j\omega G(j\omega)$ must be considered in order to relate the real part to the transient response.

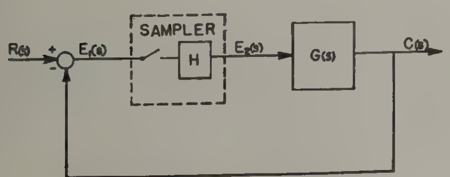

Fig. 1. Basic sampled-data system

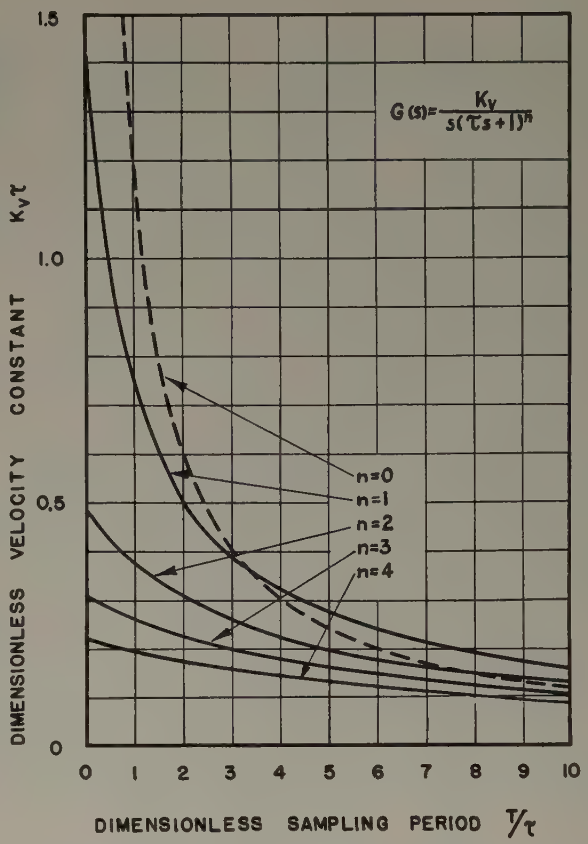

Fig. 2. Dimensionless plots of velocity constant versus sampling period for the pseudo system based on a 20-per-cent overshoot in step-function response

From dimensionless curves which describe the behavior of the pseudo system for various sampling rates, the performance of the actual system can be predicted. Fig. 2 shows the velocity constant as a function of sampling rate for a specified degree of stability. Similar curves are used to predict rise time and settling time in order to specify the transient response.

Data were derived by the use of an analogue computer. Over-all accuracies are in keeping with the approximate nature of the method, and have been shown to be reliable to within 10 per cent.

Digest of paper 54-196, "Transient Analysis of Sampled-Data Control Systems," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE North Eastern District Meeting, Schenectady, N. Y., May 5–7, 1954. Scheduled for publication in AIEE *Applications and Industry*, 1954.

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An Improved Transformer Differential Relay

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POWER TRANSFORMERS usually are protected against damage due to internal faults by percentage differential relays, which compare currents on opposite sides of the transformer. However, when a transformer is energized, there is often an inrush of magnetizing current, which flows in only one winding of the transformer, producing a differential current which tends to operate conventional percentage differential relays. Special means, therefore, are necessary to prevent transformer relays from operating falsely on magnetizing inrush currents.

Since 1938 a harmonic restrained percentage differential relay has been available which uses the characteristic waveshape of magnetizing inrush current as a means of discriminating between differential currents caused by internal faults and differential currents caused by inrush current. This relay, which has an excellent service record, now has been improved in design to produce a relay of smaller size, lower burden, and extended range of application.

The principal change involved in this design improvement is the use of a polarized relay as the main operating unit, to replace the high-burden hinged-armature unit previously used. The new relay, which is known as the Type *BDD*, is shown in Fig. 1 and is 25 per cent smaller than the old relay in over-all size. The differential circuit burden is only 1/10 that of the old relay.

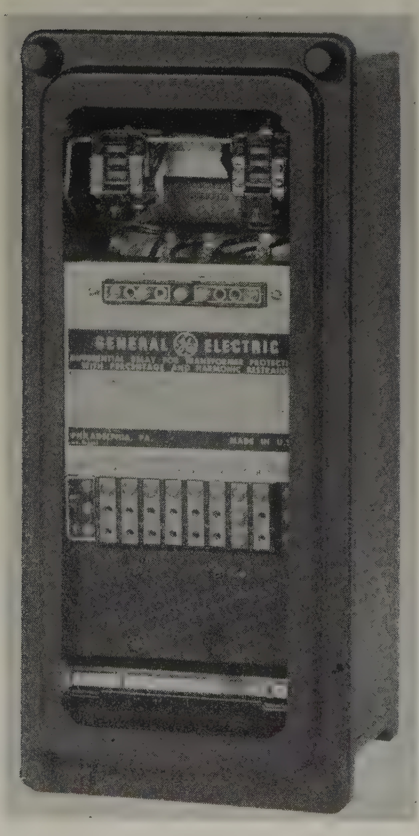

Fig. 1. Type BDD15A percentage differential relay with harmonic-current restraint for 2-winding transformer protection

The operating principle of the new relay is similar to that of the relay which it replaces. It has been shown that magnetizing inrush currents contain a large percentage of harmonics while fault currents are relatively free of harmonics. The restraint coil of the relay unit is supplied by a circuit which offers low impedance at the harmonic frequencies and high impedance to currents of fundamental frequency. The relay unit operating coil, on the other hand, is in a circuit which easily passes currents of fundamental frequency but offers high impedance to the harmonic components. Thus fault currents flow mostly into the operating coil whereas inrush currents flow mostly into the restraint coil of the main relay unit.

Restraint current also is supplied to the polarized relay proportional to the sum of the high and low side currents in order to produce a percentage differential characteristic. This additional restraint provides protection against false tripping on external faults. The per cent slope is adjustable through taps to values of 15, 25, or 40 per cent.

Since the main relay unit is restrained by harmonics in the differential current, it is possible for heavy internal fault currents to cause unwanted restraint due to harmonics produced by saturation in the main current transformers. In order to insure tripping on these heavy internal faults, the relay is equipped with an instantaneous overcurrent unit which is not restrained by the harmonic component. The pickup of this overcurrent unit is set just above the maximum expected value of inrush current.

The only application limitation in connection with this relay is the requirement that the current transformers used must have adequate capacity to supply eight times relay tap rating without saturating enough to produce more than 20-per-cent error current. With the low burden of the new relay, this is not a particularly stringent requirement, and except for the lower ratio bushing current transformers, the relay can be applied without checking current transformer characteristics.

Taps are provided on the through and differential transformers inside the relay so that main current transformer ratios can be matched without the need for any external auxiliary current transformers.

The operating time of this high-speed relay is between 1.25 and 2.5 cycles, depending on the level of fault current.

Because of the large reduction in differential circuit burden, the new relay can be used with low-ratio bushing current transformers which were not adequate to supply the old relay. The burden has been reduced to such a value that current transformer lead resistance is the principal limiting factor in establishing application limits.

Digest of paper 54-112, "An Improved Transformer Differential Relay," recommended by the AIEE Committee on Relays and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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A Transmission-Loss Penalty Factor Computer

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As systems expand, the proper co-ordination of incremental fuel costs and incremental transmission losses in the economic operation of power systems becomes increasingly important. This penalty factor computer–slide rule combination offers the advantages of simplicity, ease of operation, and accurate representation of incremental fuel costs.

THE ALLOCATION of plant generation to effect optimum operating economy has been a primary consideration of the power utility industry. A major step in the solution of this problem was the development of the incremental fuel cost slide rule[1] which provided a means of scheduling generation on an incremental fuel cost basis. For some time, however, it has been apparent that transmission losses also should be considered in the scheduling of plant loading. In the past, the system load dispatcher attempted to modify the allocation of generation with factors which approximately considered these losses. At present, the dispatcher is still without a tool which will calculate incremental transmission losses accurately and quickly, and more important evaluate them for immediate application.

Recent advances made in analyzing incremental transmission losses and the development of a practical method of co-ordinating these losses with incremental fuel costs have made possible the design of a computer, specifically for the use of the system load dispatcher. The computer described in this article will calculate, in a minimum of time, transmission-loss penalty factors which will be used to adjust the relative position of the incremental fuel strips of the slide rule so as to include the effects of transmission losses. The co-ordinated operation of the slide rule and this computer will furnish a flexible and accurate method whereby all the various and rapidly changing conditions, both within the plant and on the transmission system, may be taken into account, thus improving system economy.

HISTORICAL BACKGROUND

THE DEVELOPMENT of this computer has evolved from recent progress made in the determination and application of transmission-loss formulas. In 1943 E. E. George[2] first proposed a formula which expressed transmission losses in terms of system generation. A method of determining a loss formula with the aid of the a-c network analyzer was presented next in 1950 by J. B. Ward, J. R. Eaton, and H. W. Hale.[3] In 1951 G. Kron[4] and two of the authors[5] introduced, in companion papers, a method of determining a loss formula requiring considerably fewer measurements and calculations. The authors in these latter papers analyzed a loss formula and established its accuracy as well as its practicability in calculating transmission losses. The application of small automatic digital computers to calculate a loss formula has been discussed.[6]

Various methods of co-ordinating incremental fuel costs and incremental transmission losses have been described and analyzed.[7] The methods included the use of simultaneous linear equations[8] and a penalty factor method developed by the engineering staff of the American Gas and Electric Service Corporation and now in use on that system. The most significant results of this work established the potential saving which could be realized by utilizing co-ordination equations. As stated in this paper, the amount saved by including the effects of incremental transmission losses over the method of scheduling generation solely by incremental fuel costs was approximately $150,000 per year.

At the present time, the system production co-ordination group for the American Gas and Electric Service Corporation system is using typical penalty factor curves[9] to modify the fuel costs strips on the incremental slide rule in an attempt to include the effect of transmission losses under various system conditions. However, on a large integrated power system such as American Gas and Electric, there is a certain limit to the number of loading and operating conditions which can be taken into account, particularly in view of the large number of calculations that would be necessary in precalculating penalty factors. Furthermore, since these data are summarized in graphic form, the number of curves must be limited for practical considerations. In using these typical curves, therefore, a great deal of judgment must be used to fit them to varying system conditions which are encountered daily. Due to these limitations, it is difficult to maintain a high degree of operating accuracy under rapidly changing system conditions. It has become apparent that in order to effect a more efficient and accurate means of obtaining optimum system generation schedules, it would be necessary to design some type of computer which readily would determine penalty factors.

THEORETICAL AND PRACTICAL CONSIDERATIONS

IN reference 6 it has been shown that, for a steam-electric power system, minimum fuel input for a given

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received load is obtained by the solution of the following co-ordination equations.

$$dF_n/dP_n + \lambda(\partial L_T/\partial P_n) = \lambda \tag{1}$$

where

dF_n/dP_n = incremental fuel cost of plant n in dollars per megawatt-hour
$\partial L_T/\partial P_n$ = incremental transmission loss of plant n in megawatts per megawatt
λ = incremental cost of received power in dollars per megawatt-hour
P_n = steam plant loading

These equations may be rewritten in the form:

$$\frac{dF_n}{dP_n}\left(\frac{1}{1-\dfrac{\partial L_T}{\partial P_n}}\right) = \lambda$$

$$dF_n/dP_n(L_n) = \lambda \tag{2}$$

where

$$L_n = \text{penalty factor of plant } n = \frac{1}{1-\dfrac{\partial L_T}{\partial P_n}} \tag{3}$$

Similar equations have been derived for the economic scheduling of a combined steam and hydroelectric power system.[10] The incremental transmission loss of a given plant n may be expressed in terms of a loss formula as follows:

$$\partial L_T/\partial P_n = \sum_m 2B_{mn}P_m \tag{4}$$

where P_m = all source loadings and B_{mn} = loss formula coefficient.

Optimum generation schedules for various loads are obtained by solving either equation 1 or 2.

These equations may be solved by various general-purpose analogue and digital computers in order to precalculate schedules. However, for large systems, the number of precalculated schedules would be prohibitively great, and it would be difficult to preconceive all of the various combinations of fuel costs, plant outages, and interconnection flows that may occur. To overcome the difficulties encountered with precalculated schedules, it would be necessary to install either a general-purpose computer or a specially designed automatic computer in the load dispatcher's office. However, the costs of such computers for a large system would be considerable, particularly from the standpoint of initial investment. In addition, the complexity of this equipment would require highly skilled maintenance personnel.

To provide a simple and less costly means of determining generation schedules, an auxiliary computer was designed to operate in conjunction with the incremental slide rule. This computer which may be called a penalty factor computer, will be used to calculate both incremental transmission losses as given by equation 4 and penalty factors as given by equation 3.

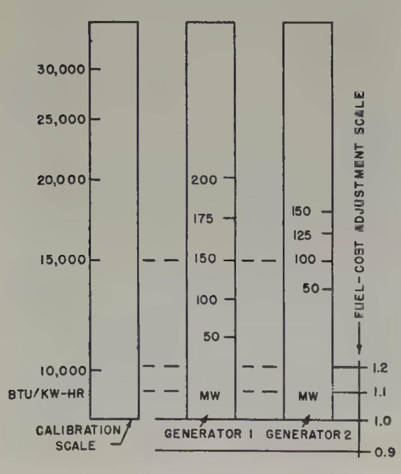
By incorporating the slide rule in this scheme, the following advantageous features of this device are retained:

1. The incremental fuel rates can be represented accurately, including all the discontinuities that may occur.
2. Strips for various turbine-boiler combinations can be prepared easily from data obtained by thermodynamic incremental studies.
3. Operation of the slide rule is simple.

Other means of representing incremental fuel rates by either electric or electronic devices are known to be feasible, but are more costly and, in general, less accurate than the slide rule.

DESCRIPTION OF EQUIPMENT

An incremental fuel rate slide rule[1] for a 2-generator system is illustrated in Fig. 1. The slide rule consists essentially of a logarithmic calibration scale, a movable strip for each generator unit, and a fuel cost adjustment scale. The calibration scale is graduated in Btu or mils per kwhr to a logarithmic scale. Each movable strip is calibrated in mw and indicates the relation between the incremental fuel rate and the output of a given generator unit. Differences in fuel costs may be accounted for by displacing a given generator strip so as to line up the bottom of the strip with a position on the fuel cost adjustment scale corresponding to the ratio of fuel costs. For a given incremental cost of received power, corresponding generator outputs then can be read directly from the strips. If the fuel costs for both generators are assumed equal, it is seen from Fig. 1 that for a total load of 250 mw, 150 mw should be scheduled from generator *1* and 100 mw from generator *2.*



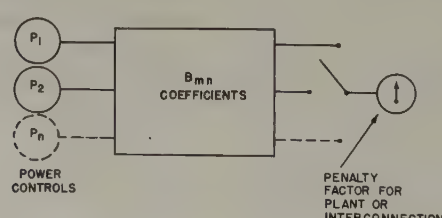


Fig. 1 (left). Incremental slide rule. Fig. 2 (above). Schematic representation of penalty factor computer

The penalty factor computer as shown schematically in Fig. 2 consists essentially of adjustable power units representing the various plant loadings and interconnection flows, a B_{mn} network, and a central penalty factor and incremental-transmission-loss meter. The penalty factor for a given plant or interconnection is read on the central meter by pressing the key for that plant or interconnection. After the power settings are made, the time for computation is negligible and is essentially that required to read the penalty factor from an instrument.

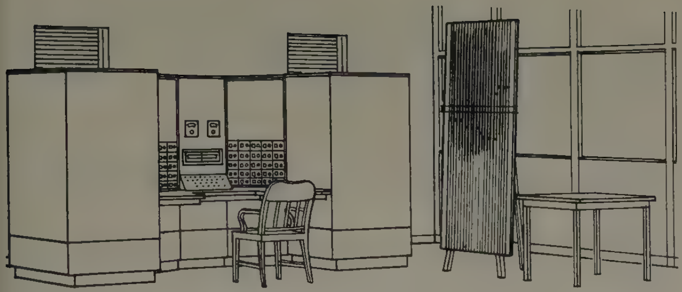


Fig. 3. Sketch of American Gas and Electric computer

A working model of this computer has been built and demonstrated. An artist's sketch of the penalty factor computer being built by General Electric for the American Gas and Electric Service Corporation based upon this model is given in Fig. 3.

PROCEDURE IN OBTAINING GENERATION SCHEDULES

The method involved in the actual hour-by-hour economic scheduling of generation is as follows:

1. Set the B_{mn} coefficients into the penalty factor computer. Once these coefficients have been set, it is not necessary to change them except for major changes in the transmission system, which normally occur because of expansion of facilities. These B_{mn} coefficients may be changed easily as required.
2. Obtain a preliminary generation schedule from the incremental slide rule, using estimated penalty factors.
3. With the generation schedule from item 2, determine revised penalty factors for all steam plants from the computer. This operation is accomplished by setting into the computer the various values of steam generation as determined from item 2 as well as the hydroelectric generation and foreign interchange flow.
4. Displace the incremental fuel rate strip of a given plant by the logarithm of the revised penalty factor. Determine a new generation schedule from the incremental slide rule.
5. With the generation schedule determined from item 4, determine new penalty factors on the penalty factor computer as in the foregoing.
6. Using the new penalty factors from item 5 on the incremental slide rule, determine a new generation schedule.

The foregoing converging method of calculation is repeated until the penalty factors used on the slide rule correspond to the generation schedule obtained from the slide rule. The rate of convergence can be increased by using a penalty factor for a given plant in steps 4 and 6 equal to the average of the old and new penalty factors for that plant. Thus in step 4, the penalty factors to be set on the slide rule for a given plant would be equal to the average of the penalty factors for that plant obtained in steps 2 and 3.

In the course of calculating the daily load schedule it is not necessary to start with step 2 each time. The usual procedure would be to obtain an initial generation schedule from the incremental slide rule using the penalty factors corresponding to the preceding generation schedule and then use this initial generation schedule in step 5.

The foregoing procedure converges quickly to the correct solution primarily for the following reasons:

1. The penalty factors are adjustments on the incremental fuel cost strips with the incremental fuel costs generally being the primary factor in determining the allocation of generation.
2. In determining generation schedules on an hour-to-hour basis only relatively small changes in generation are involved with correspondingly much smaller changes in penalty factors.

BENEFITS

The specific benefits derived from the penalty factor computer are as follows:

1. The computer will provide a means of determining penalty factors accurately and rapidly for any of the various operating conditions which are experienced daily on a large integrated power system such as system load, available steam and hydroelectric generation, and interconnection sales and purchases. The penalty factor computer, because of its flexibility, will eliminate the need for interpolation and guesswork involved in present known methods of including the effect of transmission losses on system operating economy.
2. The computer will afford savings in economic scheduling of plant generation.
3. The computer will provide a rapid means of evaluating incremental transmission losses incurred in transactions with interconnected companies.
4. The penalty factor computer will eliminate the need for the tremendous number of computations required in precalculating penalty factors.
5. The computer, which is a relatively simple device as compared to other types of computers, will be easy to operate and maintain.
6. The computer will operate in conjunction with the incremental slide rule now in use in the industry. This combination will prove a practical solution to the problem of system operating economy, particularly since the incremental slide rule, to date, is the simplest, most accurate, and most flexible device known for evaluating incremental fuel cost.

CONCLUSION

The combination of the penalty factor computer and incremental slide rule was chosen for use on the American Gas and Electric system after evaluation of several alternative methods. This scheme is felt to be practical for adoption on other systems.

As systems expand the need for properly co-ordinating incremental fuel costs and incremental transmission losses in the economic operation of power systems is becoming increasingly important because of the following trends:

1. In many cases economic factors and the availability of primary essentials such as coal, water, etc., dictate that

new generating plants be located at greater distances from the load centers.

2. Larger blocks of power are being installed resulting in the necessity of transmitting power out of a given area until the load in that area is equal to the new block of installed capacity.

3. Power systems are interconnecting for purposes of economy interchange and reduction of reserve capacity.

The proposed penalty factor computer will be of considerable assistance to operating companies in determining the optimum operation of their system. The penalty factor computer–slide rule combination offers the advantages of simplicity, ease of operation, and accurate representation of incremental fuel costs.

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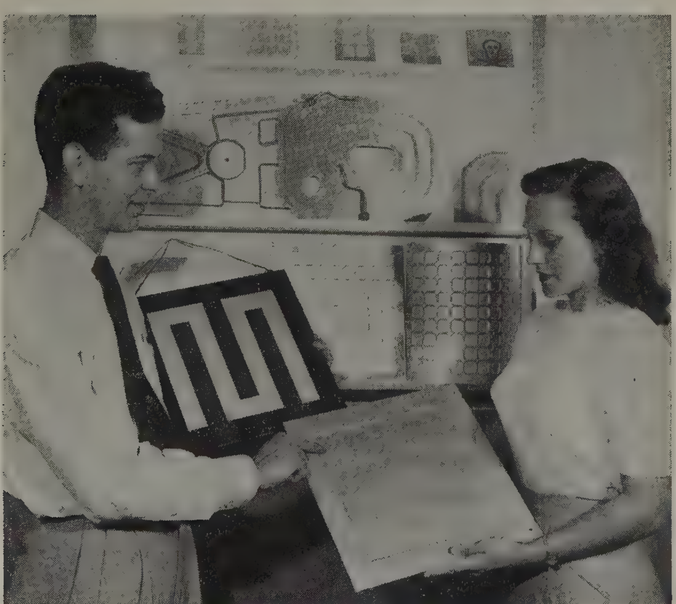
Chemical Milling Process for Aircraft and Guided Missile Parts

Precision milling of aircraft and guided missile parts without machinery now can be accomplished with the new chemical milling process developed by North American Aviation to save weight, give greater accuracy, and permit better designs, the company has announced.

Through arrangements with North American, Turco Products, Inc., of Los Angeles, Calif., is licensed to make the process available to other interested manufacturing companies.



Materials Research and Process Engineer Clayton Shepherd (left) explains working of chemical milling to Irene Harlan, another employee. The "before" sample, held by Mr. Shepherd, shows dark portions, specially masked to confine chemical milling only to desired areas. Miss Harlan is holding the finished job. Samples of work done by chemical milling are in the background

Usable by military and civilian industries, the chemical milling method removes unwanted metal from complex or fragile formed parts without danger of warpage or rejection that might result from machining. The method is equally effective in making intricate cuts and in tapering metal.

Chemical milling is not intended to replace all machining operations but to permit new, unconventional designs. Cost of chemical milling equipment is only a fraction of that for a skin mill.

Stiffened construction of wings or fuselage is possible by this method, allowing cooling or heating passages, if needed. A design similar to "sandwich" or "waffle" construction can be produced without the previous problems of machine-forming complex curves and angles.

To prepare a part for chemical milling, the metal to be removed is left exposed, while the rest of the part is masked with a specially developed coating. The entire part is submerged in an etching solution prepared by Turco Products. The solution attacks exposed surfaces evenly at a constant rate until the desired amount of metal has been etched away.

Electronically controlled, the chemical sculpturing process produces finished metal surfaces to accuracies of 0.002 inch.

Added to making possible broader horizons of design, chemical milling can lead to faster production of complex parts. With a solution tank large enough, any number of parts can be etched at the same time, greatly reducing unit costs.

Switching Surge Voltages in High-Voltage Stations

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SWITCHING SURGES, lightning surges, and 60-cycle voltages are, in general, the three types of voltages involved in the design and protection of insulation of stations and station equipment. Under switching surges may be classified various groups dependent upon the manner of initiation, the circuit parameters involved, and the circuit configuration. Of the numerous kinds of transient abnormal voltages caused by switching, the type receiving primary consideration in line and station insulation design has been that resulting from circuit breaker performance in the interruption of charging kva such as occurs in line or cable dropping or in switching a capacitor bank.

Whereas extensive field studies and surveys and studies on systems in miniature have been made on the magnitudes of voltages that may be obtained with circuit breaker restriking in the interruption of capacitive charging current—particularly the voltages that may be experienced on the line or line side of the circuit breaker—no extensive studies appear to have been conducted with regard to both voltage magnitudes and waveshape and duration of these voltages especially on the source side or station side of the line circuit breakers nor with regard to the effect of source impedance and station configuration on these surges.

It is the purpose of this article to investigate and evaluate the afore-mentioned type of switching surge requirements of modern and anticipated systems in so far as they might affect the design and protection of station and station equipment insulation. This study was carried out largely on systems in miniature on the Transient Network Analyzer, indicating station and line switching surge voltages as they might be obtained using modern breakers employing modified interrupters for the interruption of charging kva.

The stations considered in this study were based on the trend in modern and future stations which is towards unit-generating systems bussed on the high-voltage side with more power being concentrated in a single unit. In these unit schemes, the transformer is usually delta-connected on the generator side and Y-connected on the high side. Most stations will operate with the neutral of the Y solidly grounded.

For the system described, the total generating capacity of the unit schemes was taken in increments of 100, 200, and 300 megavolt-amperes (mva), it being assumed that these generating capacities are the result of parallel combinations of several unit schemes or the total capacity of one such unit. For these various generating capacities, high side voltages of 138, 230, and 330 kv were considered.

In these systems, the dropping of a line or even the switching of a faulted line may result in switching surge overvoltages associated with the interruption of charging kva. In the case of a single line-to-ground fault, for example, two phases are called upon to interrupt capacitive currents if the line breaker at the far end of the line opens first. In a large station from which many lines radiate, the condition adopted for the purpose of this study of switching surge voltages is a bus section with three outgoing lines, the assumption being that with one line out of service for maintenance the other two may be tripped automatically in rapid sequence. Thus, switching surges may be initiated involving one or more lines on the bus with a minimum or maximum generating capacity. It should be understood that the system condition described here is not necessarily the one that gives rise to the highest switching surge voltages in the station but rather a possible system condition demonstrating that voltages on the order of arrester spark-over can be obtained.

The results of the study indicate:

1. In modern and anticipated generating stations in effectively grounded systems using line circuit breakers that will not restrike more than once per phase during an interruption and not employing resistance shunted contacts, switching surges in excess of lightning arrester spark-over may be obtained on the station bus.
2. These voltages will be oscillatory in nature and may require longer than 1,500 microseconds to reach the crest value. Certain circuit configurations may increase this time to as long as 4,500 microseconds.
3. The magnitude of the station surge voltages was not affected appreciably by the generating capacity of the station. The time to the crest voltage decreased with an increase in the source mva.
4. The magnitude of the station surge voltages tends to decrease with an increase in the amount of unswitched line on the bus whereas the time to the first crest tends to increase.
5. The surge voltages on the line are higher than on the bus by approximately 50 per cent thus subjecting circuit breakers to higher switching surge voltages than transformers in stations unless limited in magnitude by arresters on the line side of circuit breakers.
6. Initially, on restrike, the station bus and transformer voltage can undergo a rapid change in voltage from crest value of one polarity to crest value of the opposite polarity in a time on the order of 10 microseconds.
7. The station surge voltages were of the same magnitude when switching line-to-ground faults as when switching an unfaulted line.

Digest of paper 54-84, "Switching Surge Voltages in High-Voltage Stations," recommended by the AIEE Committee on Substations and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Power Apparatus and Systems*, February 1954, pp. 69–79.

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The Equivalent Circuit of the Schräge Motor

C. L. SHENG

THIS ARTICLE presents the equivalent circuit of the Schräge motor in a rationalized form. The secondary winding and the adjusting winding, instead of being represented by two parallel equivalent impedances, now are represented by a single equivalent impedance.

The secondary winding and the adjusting winding are considered as one winding, and is termed the combined secondary winding. The total induced electromotive force in the combined secondary winding, $(s\check{E}_2+\check{E}_3)$, is balanced by a voltage $-\check{E}_1$ in the primary winding, and the current in the combined secondary winding, $\check{I}_2$, also is balanced by a current $\check{I}_2'$ in the primary winding. The ratio of $-\check{E}_1$ to $\check{I}_2'$, or $Z_2'=R_2'+jX_2'$, is the equivalent impedance of the combined secondary winding in primary terms. $-\check{E}_1$ is derived from $s\check{E}_2$ and $\check{E}_3$, the phase relations and turn ratios being taken into account; $\check{I}_2'$ is derived from $\check{I}_2$ by considering their magnetomotive forces. The expressions for R_2' and X_2' are as follows:

$$R_2'=\frac{[(1+s)b\cos A+s+b^2]a^2R_2+(1-s)sba^2X_2\sin A}{(1+2b\cos A+b^2)(s^2+2sb\cos A+b^2)} \tag{1}$$

$$X_2'=\frac{[(1+s)b\cos A+s+b^2]sa^2X_2-(1-s)ba^2R_2\sin A}{(1+2b\cos A+b^2)(s^2+2sb\cos A+b^2)} \tag{2}$$

where

a = ratio of primary effective turns per phase to secondary effective turns per phase.
b = ratio of adjusting winding effective turns per phase to secondary effective turns per phase.
R_2 = total resistance per phase of the combined secondary winding.
X_2 = total leakage reactance, per phase at line frequency, of the combined secondary winding.
A = angle by which the axis of the adjusting winding is displaced from the axis of the secondary winding in the direction against motor rotation.
s = slip of the motor.

By connecting the magnetizing impedance $Z_m=R_m+jX_m$ in parallel with Z_2' and connecting the primary leakage impedance $Z_1=R_1+jX_1$ in series with the parallel combination, an equivalent circuit similar to that of the ordinary induction motor is formed.

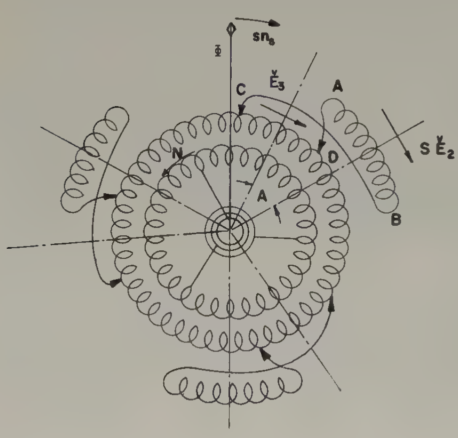

Fig. 1. Schematic diagram of the Schräge motor

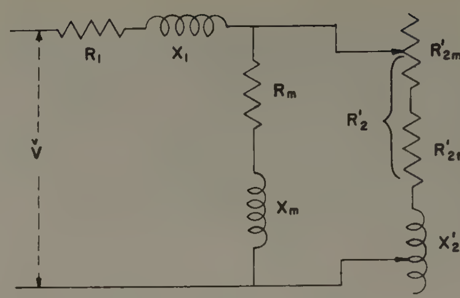

Fig. 2. Equivalent circuit of the Schräge motor

As in the case of the ordinary induction motor, R_2' can be separated further into two parts, R_{2t}' and R_{2m}', where R_{2t}' represents the true resistance of the combined secondary winding in primary terms, and R_{2m}' represents the mechanical load. The expressions for R_{2t}' and R_{2m}' are as follows:

$$R_{2t}'=\frac{a^2R_2}{1+2b\cos A+b^2} \tag{3}$$

$$R_{2m}'=R_2'-R_{2t}'=\frac{(1-s)[(b\cos A+s)a^2R_2+sba^2X_2\sin A]}{(1+2b\cos A+b^2)(s^2+2sb\cos A+b^2)} \tag{4}$$

The adjustable-speed and adjustable-power-factor nature of the motor can be seen from the equivalent circuit. The no-load speed n_o can be varied by varying the angle A and therefore is a function of A. n_o can be determined by considering the fact that at no load there is no mechanical output. The expressions for the slip at no-load, s_o, and the no-load speed n_o are as follows:

$$s_o=\frac{-bR_2\cos A}{R_2+bX_2\sin A} \tag{5}$$

$$n_o=(1-s_o)n_s=\frac{R_2+b(R_2\cos A+X_2\sin A)}{R_2+bX_2\sin A} \tag{6}$$

It can be found easily that n_0 is maximum when A is 0°, n_o is minimum when A is 180°, and n_o is still the synchronous speed when A is ±90°.

From equation 2 it is seen that X_2', instead of being constant as in the case of the ordinary motor, is a variable and is a function of A. It can be found that when A is 90°, the power factor of the motor is improved without affecting the speed.

Speed control and power factor improvement can be done at the same time. When A is between 0° and 90°, the speed is raised above synchronism with an improvement of power factor, and when A is between 90 and 180°, the speed is lowered below synchronism with the power factor improved.

Digest of paper 54-97, "The Equivalent Circuit of the Schräge Motor," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Power Apparatus and Systems*, April 1954, pp. 114–8.

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An Application of Operations Research in the Power Field

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FELLOW AIEE

The science of operations research and the tremendous advances in machine computation are two recent developments which are being utilized effectively in an analysis of an economy loading study of hydro-thermal electric systems. This research program is being sponsored by the Bonneville Power Administration at the Massachusetts Institute of Technology.

OUR NATURAL resource of water in our river, lake, and ground water systems, in addition to being a raw material for industry and the life blood of the land irrigation systems, also represents a potential source of energy. Water as delivered at higher elevations possesses an energy quotient which in itself is a much-needed natural resource. One thousand acre-feet of water 1,000 feet above sea level represents over 1,000,000 kwhr of electric energy. The converting of a small part of this energy by means of hydroelectric generating plants in no way destroys or contaminates the water which passes down the stream. Since it is not possible to store electric energy in any practical quantity the engineer looks to the reservoir as one means of storing energy, and in fact, increasing the energy yield as the reservoir height behind the dam increases. The creation of systems of dams not only makes possible the conversion of part of the available energy to electrical outlets, but enhances the availability of water for industry use, including that of irrigation, provides the energy for pumping part of this water to higher levels, and provides flood protection to the inhabitants of the valley when needed. The local importance of this potential hydroelectric energy naturally varies depending upon the future availability and costs of other energy sources such as coal, oil, and atomic sources.

One has but to analyze the industrial expansion of the Northwest under the low-cost power rates resulting from Columbia River hydroelectric power development to realize the importance of electric energy to the growth of the area, although the river always has provided ample water for other industrial purposes. With this development the flow of the Columbia River and its tributaries continually is being modulated for the benefit of the entire area. Considered as a whole this great dynamic system, discharging millions of tons of water daily, is believed to be the largest dynamic system ever to come under the direct control of the engineering profession. The skillful and efficient control of this water system, converting part of its potential energy to electrical form, transmitting and distributing this energy for industrial, rural, and household use as and when it is needed, represents one of the greatest manufacturing and merchandising marvels of our time. This is particularly true when it is realized that electric energy as a manufactured product, unlike shoes or steel, cannot be stored for later delivery but must be utilized the moment it is manufactured. As if these were not enough problems with which to contend, nature adds the fickleness of her variable rain and snowfall requiring that the storage and use of water today must be influenced by the uncertainty of constant flow in the future. At infrequent intervals nature seems to go on a strike and fails to deliver sufficient quantities of the raw material for this manufacturing process. This emergency also must be planned and prepared for well in advance. Add to the foregoing the numerous system limitations in the operation of the system, such as keeping certain channels sufficiently full for navigational purposes, providing water for the logging industry, providing ample reservoir capacity to catch part of the spring snow melt, and many others, and one will begin to appreciate the magnitude of the problem facing operating personnel of a large hydroelectric system.

Fortunately, and with good engineering and economic foresight, the hydroelectric system always is supplemented and fortified with numerous interconnections to steam generating capacity. At first glance it might appear that such reliable, but more costly, energy sources would be used when there was insufficient water to generate the essential loads. This is true; however, the interrelations are more subtle requiring a well-analyzed plan of operation which will maximize the long-range manufacture of electric energy, and/or minimize the cost of total generation over an annual period. A simple example will make this fact evident: Realizing that the output of the hydroelectric generator is a product of the quantity of water discharged and the "head" or height of water behind the dam, it follows that it is prudent operation to keep the reservoir head high as long as possible over any storage drawdown period since the energy yield in all subsequent flow will be increased proportionally. It therefore follows, in considering a long-range energy program, that steam genera-

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The writer acknowledges the assistance of Peter Schweitzer and Lucia Hunt in the preparation of this report; the work of John Littel in the department of physics, under the direction of Professor Philip Morse, together with the counseling of Professor Philip Franklin in the field of mathematics; and the work, contributions, and suggestions of numerous technical personnel at the Bonneville Power Administration, Portland, Oreg. Among the contributors to the program of study were R. J. Cypser, "The Optimum Use of Water Storage in Hydro-Thermal Systems," doctor of science thesis, Massachusetts Institute of Technology; and P. Johannessen, "Transmission Loss in the Long-Range Problem," E. Greve, "Determination of Power System Transmission Losses," and J. Carey, "Short-Range Load Allocation," master of science theses, Massachusetts Institute of Technology.

tion frequently can be justified even at a time when sufficient water storage is available to supply the load, namely, on the basis that the cost of generation over an annual period will be minimized and/or the total energy developed will be maximized.

These and other problems are being met and solved daily by the engineers and operating personnel of the Bonneville Power Administration (BPA) and other utilities of the Northwest Power Pool. However, the BPA generating system under control at the present time is relatively small in comparison with the system a few years hence when the much needed generating capacity will be increased markedly, using the same water system. The complexity of the problems of optimum system operation also increases with the size of the system. Accordingly, engineering personnel are developing new and more rapid methods of arriving at the highest possible efficiency of operation of the future system as a whole. A part of this problem has been delegated to the electrical engineering department at the Massachusetts Institute of Technology (MIT) which now is engaged in the second year of research in the "Economy Loading Study of Hydro-Thermal Systems."

Before describing a summary of the work on this project it is of primary interest to those interested in water conservation that, in general, when the operation of the hydroelectric system is made most efficient, the water resources are conserved automatically to the maximum extent commensurate with the safety from flood. In addition, the techniques developed are useful in the planning of the use of water resources for industry where electrical generation may not be necessarily a component factor. In the Pacific Northwest the supply of water for the irrigation of the Columbia Basin Project, for example, is a planned procedure which is integrated into the economy of the operation of the river system described in the foregoing. The technique provides for determining the optimum periods of pumping water to the irrigation storage channels which not only fulfills the irrigation needs but provides optimum operation of the energy conversion system using the remaining water. It is further interesting and essential to show that one of the most important lessons from this study is that water use for industry in a given valley area, to be most efficient, must be analyzed, planned, and integrated as a whole in order to capture the maximum benefits to all users. These facts have been well demonstrated by the splendid co-operation with the Northwest Power Pool where power, industry, and agricultural interests all plan for the mutual good of the inhabitants of a large integrated area.

Two very important developments during recent years in the field of the analysis of large industrial enterprises are utilized effectively in the analysis of our economy loading study of hydro-thermal electric systems. These are (1) the science of "operations research," and (2) the tremendous advance in the field of machine computation of complex problems which in turn has made possible the quantitative consideration of numerous operational problems hitherto thought impossible of solution. These two tools work hand in hand to shed light on the optimum operation of large hydro-thermal electric systems.

Operations research, in the broadest sense, is the application of the scientific method to the study of the operations, modification, and planning of large complex organizations or activities in order to give executives a quantitative basis for decisions that will increase the effectiveness of such organizations in carrying out their basic purposes.* The link to the application to modern computing machines lies in the quantitative approach to the problem. By expressing the interrelation of water flow, reservoir elevations, tail water elevations, reservoir capacity, expected load requirement, etc., to the energy generation characteristics, efficiency with discharge characteristics, steam cost, electrical losses, etc., of all the generating plants on the system and optimizing the energy over a given time interval, it has been possible to arrive at operating criteria which minimize the cost of operation over the period. Such solutions have been made on large digital computers by an iterative process. The mathematical concepts employed include a knowledge of the calculus of variations. Such solutions are based inherently on a known fixed water flow and load requirements over the assumed period and are only useful as such flows and loads are realized. Such solutions aid in establishing certain axioms of efficient operation and certain "norms" of maximum possible energy production, under specified flows and loads, over an annual period, but in general are too complex to be used as a guide to the weekly operation of the dynamic system. The weekly, daily, and sometimes hourly variations in the load, flows, and generating conditions, often created by the unexpected, give rise to the need for a more rapid and flexible means of computing the most efficient system operation during the few days immediately ahead. The daily and weekly solution of this operation problem is being carried out by a remarkably small staff of engineering personnel at BPA who make full use of daily reports of system conditions, weather forecasts, tables of system characteristics, desk calculators, and a considerable amount of ingenuity, all of which is enhanced with a backlog of system experience which, of course, is invaluable in making rapid engineering estimates to minimize the number of iterative longhand solutions to arrive at the optimum operating plan. Although quite efficient at the present time in solving a difficult problem with limited manpower, the water resources group at BPA seeks the development of a simplified digital computer capable of, first, taking over the longhand iterative solution of the present system. Second, it must be capable of extending the solutions to include the more complex generation and load patterns as the systems take on new dimensions during the next few years. Third, it must accomplish these results more rapidly, more effectively, and with the same personnel. These aspects are being studied both by BPA and the MIT department of electrical engineering under contract.

THE FIXED-FLOW PROBLEM

In the "fixed-flow" approach to the problem, it is assumed that the flows and load for the entire storage-use season are known in advance—as contrasted to the "probabilistic" approach, in which only certain probability

* A similar definition appears on page 106 of the April 1951 issue of *Fortune*.

distributions (obtained from historical records) are assumed to be known. Once some quantitative criterion of good system operation is chosen, the fixed-flow problem may be formulated in a straightforward manner as a problem in the classical calculus of variations, except for the fact that account must be taken of various system constraints. These constraints can be included by means of standard devices in the calculus of variations; this procedure, however, would appear to lead to great computational difficulties. One possible alternative is to allow breaking of the constraints, but to make it unrewarding to do so, by the introduction into the problem of certain artificial "penalty functions," which assure that system operation is never good (by the criterion chosen) when constraints are violated. This reduces the problem to that of minimizing an integral, which may be done in the usual way by solving a set of differential equations. Their solution then yields a set of curves showing the optimal elevations of the various reservoirs at all times throughout the storage-use season, as contrasted with the solution of the probabilistic problem, which consists of a set of rules prescribing what action to take at each reservoir under given circumstances at any given time in the storage-use season. The principal difficulty, then, lies in the solution of certain differential equations, which are nonlinear. For a large hydroelectric system, their solution requires not only careful study of the equations and of the underlying problem, but very extensive computing facilities.

A comparison with similar analysis of the operation of predominantly all steam systems is of interest. Here the energy value of coal in Btu per ton is an essentially constant value. A rough approach to the hydroelectric analysis would be realized if the energy of coal in the yard was also a function of the quantity of coal, simulating the increase in available energy as the water is allowed to be stored in the reservoir. Accordingly, the differentials in available hydroelectric energy are so great as to minimize the importance of transmission-line losses and refinements in the latter are in many cases of little consequence in the present analysis of the problem.

THE STATISTICAL-FLOW PROBLEM

One possible approach in the probabilistic case is use of the so-called "Monte Carlo" method. Its application to this problem is as follows. After statistical analysis of the historical river flows, a large number of fictitious flows are generated which are realistic in the sense that their pertinent statistical characteristics are the same as those of the historical flows. Here the question of what statistical characteristics are "pertinent" is not an easy one, however a very important one, whose answer requires considerable insight into the nature of the system. Using these flows, it is possible to simulate many years of system operation in a short time. Thus one can choose an operating policy for the system, simulate many years of system operation using that policy, and examine the results of the operation from any point of view desired. This procedure might be used to compare two operating policies, especially if it is desired to compare them on some points which cannot be expressed readily in quantitative form. The advantage here of using the fictitious flows rather than, or in addition to, the historical flows, is that the number of recorded historical flows is rather small; there are many types of flow which have not occurred during the recorded period, but which are likely to occur in the future. Testing a policy on the historical flows will not reveal its consequences if it is in use when one of these unrecorded types of flow occurs; testing it on a large number of the fictitious flows is likely to do so.

A more refined use of the Monte Carlo method is possible, and might be useful in a somewhat different way. Given an operating policy containing one or more variable parameters, and a quantitative criterion of good system operation, it is possible to use the fictitious flows to find those values of the parameters that give the best operation. This method could be used to find a solution to the general storage-use problem; the practicability of obtaining a solution in this way, and to a lesser extent the value of the solution obtained, depend very heavily on a judicious choice of the general form of the operating policy and of the parameters to vary. Needless to say, these choices require great familiarity with the particular system.

Another possible probabilistic approach is more direct. Instead of using probability distributions obtained from the historical flows to generate fictitious flows, the distributions may be used directly to set up a general expression for the long-term "expected value" of any quantitative criterion of system operation. This expected value then can be optimized with respect to all possible quantitatively expressible operating policies in a very large class. This method, if it can be made practicable by taking advantage of the characteristic features of the particular system, does not necessitate the afore-mentioned choices, and yields a more exact solution than the Monte Carlo technique. It is less versatile than the foregoing methods with regard to admitting nonquantitative evaluations, and it loses much of the intuitive appeal of those methods—a point which could be of importance in connection with presentation of the final results to operating personnel.

OTHER OPERATIONS RESEARCH OPPORTUNITIES

In the foregoing discussion the essential consideration was the prudent operation of a large complex system to achieve the maximum load-carrying ability with due consideration to cost. Characteristic of the engineering profession, the parameters under control can be expressed relatively accurately in mathematical terms. The interrelation and computation of such analytical relations comprises the essential ingredients of a problem in operations research. Such has been the technique employed in the study of large hydro-thermal electric systems.

It follows, however, that still greater opportunities for the application of the techniques of operations research lie in the area of system and project planning. For example, if two or more alternatives are under consideration to add new reservoir and generating capacity to any system, the relative merits of the several plans are subject to analytical analysis by the techniques of operations research. In a similar manner these techniques can be applied to many facets of the hydro-thermal electric problem

or any system. Several will be indicated in the following:

1. As a Management Guide

(*a*). To indicate the optimum sequence of drawdown and refill characteristics for each reservoir over a short time and annual period which will minimize the cost of added steam or purchased power to the pool under practical limitations, using estimated flow and load characteristics over the period and giving strict attention to peaking requirements.

(*b*). To indicate the scheduling of a given quantity of irrigation water over a given annual period which will result in the minimum of added steam to the pool over the annual period as compared with other methods of extracting the same amount of water, or to evaluate the relative cost or loss of energy as a result of any predetermined scheduling of irrigation water.

(*c*). To indicate the optimum time to require that displacement steam be added to the pool, how long it should be added, and in what quantities so as to optimize the total power resources of the pool or to minimize the total operating cost.

(*d*). To indicate quantitatively the relative long-term merits in terms of energy or cost of dropping specific loads for given periods and to evaluate this practice quantitatively in relation to several long-range alternatives.

(*e*). As a guide to the establishment of more profitable contractual agreements and rate structures for sold, purchased, displaced, and dump energy.

2. As an Operating Tool

3. As a Means of Evaluating Limitations

To establish numerically the annual savings which would result by operating without any one of several correctable limitations. Such studies would indicate the justifiable expenditures to be directed toward the elimination of such limitations or their avoidance in future projects.

4. As a Project Planning Tool

To seek out and demonstrate on a long-term financial quantitative basis the optimum design characteristics of a given proposed project with respect to each of several design parameters such as:

(*a*). Head and usable draft.

(*b*). Pondage characteristics.

(*c*). Amount of generation—reactance and control.

(*d*). Interconnection to power grid—voltage and reactance.

(*e*). Tail race fluctuations with discharge.

(*f*). Optimization of transmission losses.

(*g*). Optimum maintenance schedules.

(*h*). Avoidance of limitations, etc.

5. As a Multipurpose Planning Tool

To evaluate and compare, quantitatively, the engineering and economic merits of adding one of several new multipurpose or generating plants to the hydroelectric pool, each of which could be considered optimum for the location as described in item 4.

6. As a Guide to the Importance of Establishing Accurate Flow Forecasts and Load Estimates

Solutions of the economy loading problem, using small differences in flow forecasts or load estimates, will reveal the financial loss to be achieved as a result of each 1-per-cent error in forecast. Such evaluations will indicate the practical limits of expenditure which are justified to achieve each additional 1 per cent in accuracy of the forecast of flow or load estimate.

7. As a Guide to the Location of Loads

New loads added to the system can be so located as to produce the minimum of additional transmission-line losses. A knowledge of these locations is of value to the electrical and industrial growth of the system. A knowledge of preferred locations can be evaluated, in turn, with respect to the location of new hydroelectric facilities or the areas for optimum steam generation.

These ultimate objectives of the economy loading problem applied to any system are comprehensive although not idealistic. Successful solutions in other fields prove the value and scope of the techniques of such an analytical approach to operation and growth of large complex organizations.

The encouraging factors in favor of the success of the study as applied to the BPA system are

1. A large background of practical experience in operating the system.

2. A growing fund of available statistical and factual information covering all essential ingredients of the problem.

3. A co-operative staff trained in the engineering approach to their problems.

4. A demonstrated enthusiasm in all branches for attacking the whole problem in a comprehensive manner, under the guidance of:

5. An enlightened management whose foresight and vision initiated the present study and encourages its progress.

The thought of applying the analytical technique of operations research to the distribution and utilization of a specific natural resource in a limited geographical area or on a national scale is an appealing one. The natural resource of water, its distribution and use in a specific valley area, is particularly adaptable to these techniques. A long-range planning program of area development considering the need for water and its partner, energy, can go a long way in guiding industry selection, location, and growth which can be balanced with the resources on a long-term basis. On a fixed water supply basis in a given area the requirements of a growing industrialization are for more water and, particularly, more energy. In such an economy a decreasing amount of water will be available for energy which will require greater utilization of the natural sites for energy generation. For a time such facilities will provide more readily available energy and water for industry use throughout the entire valley. Eventually, however, more steam generation (coal, oil, gas, or atomic fired) will and must be added in greater quantities to meet the demand of industry, rural, and domestic needs and to insure the availability of sufficient energy. The study and analysis of such problems opens a challenging opportunity to the field of operations research. Present-day planning, therefore, should not be geared to the immediate needs of a small part of the area but to the welfare of the entire region during the next 20 to 50 years.

Calculating Amplitudes in Transient Responses

D. G. LEWIS
ASSOCIATE MEMBER AIEE

THE IMPORTANT RESULT in many studies of transient response is the maximum displacement experienced by one or more parts of the system. It is possible to calculate this maximum value directly from the system response function, without inspecting a complete plot of the response.

The transient responses of many dynamical systems with relatively simple driving functions can be obtained readily by operational methods. In many cases, however, the form of the response does not lend itself to a quick calculation of the desired result. A typical example is a system having two or three natural frequencies, driven by a damped sinusoid at a frequency near but not coincident with one of the natural frequencies. If the problem is to find the maximum excursion which a given point in the system will reach, the determination of the response function is only the first step in obtaining a solution. If the actual maximum excursion then is found by point-by-point calculation from the response function, this second step in completing the solution may be more time-consuming than the first, even with the use of automatic computing devices. Since usually a number of sets of parameters will be of interest, and since the response function often can be derived literally, thus applying to all sets of parameters, the tedium of point-by-point calculation to find the maximum becomes less and less attractive.

The problem can be illustrated by considering a 3-unit turbine-generator set in transient torsional vibration following a generator short circuit. To proportion such a set properly, the designer must have some means of estimating the shaft torques which will develop under severe transient conditions. A convenient base for this estimate is a calculation of the shaft torque following 3-phase short circuit. It is possible to derive literal expressions for these transient shaft torques, neglecting mechanical damping but considering the rapid decay of the applied electric torque. These expressions then can be manipulated to allow a direct calculation of the maximum torque which requires much less effort than the alternate procedure of point-by-point calculation.

It is assumed that the differential equations of the system in question have been solved by operational methods, and that the solution for one of the variables appears in the form of equation 1.

$$\begin{aligned}F(t)=&A_1\,\epsilon^{\alpha_1 t}\sin(\beta_1 t+\phi_1)\\&+A_2\,\epsilon^{\alpha_2 t}\sin(\beta_2 t+\phi_2)\\&+A_3\,\epsilon^{\alpha_3 t}\sin(\beta_3 t+\phi_3)\\&+\ldots\ldots\end{aligned} \tag{1}$$

In this equation, one of the β's represents the frequency of the driving function; all the others are natural frequencies of the system. All but one of the α's may be zero. If all are zero, the maximum excursion is simply the absolute sum of the A's, assuming incommensurable frequencies.

This equation is fundamentally a means of calculating the excursion at any specified time, the α's and β's being dependent upon the system parameters, and the A's and ϕ's being dependent upon the initial conditions and the magnitude of the driving function. The problem in finding the maximum is therefore the problem of finding the time at which the maximum occurs. This can be done rather easily by making use of two assumptions:

1. The maxima of $F(t)$ will occur at or near times at which one of the individual terms of $F(t)$ reaches a maximum.
2. Near the maxima of $F(t)$, the function is approximately parabolic.

The term "maximum" as used here includes both positive and negative values; the direction of the maximum displacement is taken to be unimportant.

The first assumption establishes points at or near which the maxima of $F(t)$ must occur. The second assumption allows $F(t)$ to be expressed as a 3-term Taylor's Series in the vicinities of these points. By expanding the series about these points of predicted maxima, it is possible to calculate a more accurate set of points. Substitution of these improved points in the series expressions yields the successive maxima of $F(t)$, from which the greatest may be selected as the result of the problem.

Before any result can be accepted, it is necessary to check the validity of assumption 2. This check can be included then as a simple part of the numerical calculations for each point.

The calculations associated with the method proposed in this article can be done by hand, at least for the simpler applications. For problems in which the response contains more than two natural frequencies plus a driving frequency, the use of an automatic digital computing device is justified.

It is to be noted that any of the problems for which this method is suitable also can be solved by the use of analogue computing devices. The choice between the two types of computation depends on the number of times the problem is expected to arise, and the number of cases which must be investigated each time. Analogue calculation has an advantage in the number of cases per unit of time once the computer connections are complete; a digital calculation using the method described here has an advantage in the time required to arrange the computer, and therefore is superior if the problem is expected to arise again and again.

Digest of paper 54-192, "The Direct Calculation of Maximum Amplitudes in Transient Responses," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE North Eastern District Meeting, Schenectady, N. Y., May 5–7, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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Properties of Optimum Power Transformer Design

H. L. GARBARINO
ASSOCIATE MEMBER AIEE

THE DESIGN of electronic power transformers and other electromagnetic devices usually presents so many requirements with regard to choice of materials, thermal limitations, circuit characteristics, and insulation problems that it is difficult to obtain the best design from the standpoint of weight, volume, losses, or cost. After choices of insulating, magnetic, and conducting materials have been made, the most important requirements for an optimum transformer design are use of satisfactory proportions, selection of type of core construction, and use of an optimum core flux density.

Three types of core construction commonly used for single-phase transformers are termed: the simple, which has one window and a coil structure around one core leg; the shell, which has two windows and three legs, with one coil structure located on the middle leg; and the core, which has one window and two coil structures located on opposite legs. For each type the shape (not size) is uniquely determined by three proportions: the ratio of the two window dimensions, the ratio of the two core cross-section dimensions, and some ratio to express the proportion of winding size to core size. One ratio which can be used for the latter is window area to core cross-sectional area, A_c/A_i. Of the three geometric proportions, the best values for the first two, ratio of window dimensions and ratio of core cross-section dimensions, are almost constant, but the third should be varied according to the quantity to be minimized.

A general approach, applicable for studying total weight, volume, losses, or cost, is possible through the use of a winding to core weighting factor K. This is the ratio of some quantity per unit volume of the winding to that same quantity per unit volume of the core. Thus K for losses might be the ratio of watts per cubic inch of the winding structure to watts per cubic inch of the core structure. Since weighting factors for weight, volume, loss, and cost are usually different, it is not possible to minimize all four quantities. It is desirable to study all four simultaneously because there is no need to obtain the exact best proportions to minimize one of the four, but it is desirable to find how the others are varying. A negligible sacrifice in the one being minimized can reduce one or more of the other three.

Fig. 1 gives total weight, volume, losses, or cost as ordinates versus ratio of areas for the simple type of core construction. An assumption made is that total winding weight, losses, or cost is proportional to winding volume, and similarly for the core. Ordinates of Fig. 1 should be compared only for the same parameter K. For example, K for weight is usually small, perhaps 0.2 to 0.4. If weight were being minimized, then a large ratio A_c/A_i should be chosen, in the order of 3 to 4. However, K for losses is usually high for low-frequency transformers, perhaps 2 to 3, and K for volume is always 1. A design for minimum weight has much higher losses than could be obtained if the design were made for minimum losses, as illustrated by the rising $K=2$ and $K=3$ curves at $A_c/A_i=3$ or 4. A reduction in A_c/A_i to 2 would aid losses and volume, without much increase in weight from its lowest possible value.

When best proportions of each type of core construction are found, it is a simple matter to compare types for various values of the weighting factor K. On this basis the shel type is most economical for large K, while the core type i best for small K.

Another important consideration in design is the choice of flux density. In general, permissible limits for flux density might be established either by core losses or excitation current. In most low-frequency electronic power transformers, winding losses rather than core losses determine the permissible core flux density and winding current densities. Thus the heating due to excitation current in the primary affects permissible flux density. In a transformer operated at its optimum flux density, there is a maximum volt-ampere output for a fixed value of total winding losses. The optimum density is evidentl between two extremes. At very low densities, output is low because voltage is low. At a very high density, winding losses due to excitation current are so great that no load may be placed on the secondary.

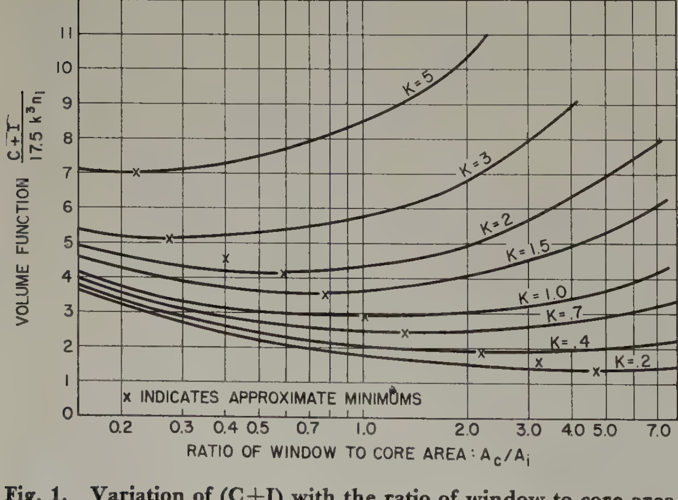


Fig. 1. Variation of (C+I) with the ratio of window to core area (simple-type core)

Digest of paper 54-118, "Some Properties of the Optimum Power Transformer Design," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

H. L. Garbarino is with Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

This paper presents part of the results of an investigation conducted for the Signal Corps Engineering Laboratories and Wright Air Development Center under Contract No. DA 36-039 sc-5519.

INSTITUTE ACTIVITIES

North Eastern District Holds Successful Meeting in Schenectady

With the AIEE Schenectady Section as host, a very successful 3-day meeting of the North Eastern District was held May 5–7, 1954, with headquarters in the Hotel Van Curler. Built around the theme that research and engineering are the pillars of progress, 16 technical sessions on timely subject matter were held during the 3 days. The inspection trips, an evening smoker, and buffet supper followed by the Steinmetz Memorial Lecture all proved popular. A ladies' program was arranged under the chairmanship of Mrs. W. C. White. The total registration for this year's meeting was 870.

TECHNICAL SESSIONS

Semiconductors. Exemplifying the theme of the meeting, four papers were presented in a session on semiconductors with Dr. W. C. Dunlap, Jr., presiding.

By means of simple diagrams of physical models, Dr. J. M. Early, Bell Telephone Laboratories, explained the operation of junction diodes and transistors with the derivation of their characteristics. Particular emphasis was placed on the capabilities of these devices in respect to voltage, power, and frequency as well as the limitations imposed by temperature.

In the second presentation, "Electroluminescence," Dr. J. F. Waymouth of Sylvania Electric Products, Inc., discussed the theory of direct conversion of electric energy to luminescent energy as well as the surface brightness characteristics of zinc sulphide, copper, and lead-actuated phosphors. In reviewing the present status and probable future status of luminescence, Dr. Waymouth explained that the stability of the dielectric due to water vapor had to be overcome which has been done by making ceramic lamps. In conclusion, he said that an area source is ideal for general illumination purposes and that it is a mistake to feel that the present level of illumination is all the brightness that can ultimately be obtained.

In the light of rapid developments in solid state physics and transistor physics since the last war, Dr. R. G. Seed of Transistor Products, Inc., classified photo-sensitive materials and devices into five general types and developed the equations for currents and voltages across any photo-multiplying rectifier junction as well as equations for power conversion, efficiency, noise frequency, frequency response, and signal-to-noise ratio.

In the last presentation of the session, Dr. V. C. Wilson of the General Electric Company discussed "The Ferrites" in the light of the development of a new tool, the double crystal spectrometer which will enable one to look inside of magnetic materials by examining the peaks of neutron intensity. There are a great many magnetic materials that are just as tightly locked up electromagnetically as iron; if more is learned about antimagnetic couplings, more will be known about ferromagnetic couplings. In conclusion, Dr. Wilson mentioned several applications of the ferrites such as transistors of small ferrites for use in computers. He pointed out that the Massachusetts Institute of Technology (MIT) is using small rings as memory storage devices since one ring can be made to act as a flip-flop device, requiring less power and replacing two tubes.

During a North Eastern District Meeting inspection trip, C. E. Kilbourne, far left, explains a large General Electric turbine rotor to (left to right): President Robertson; H. A. Winne, retired General Electric vice-president; and Dr. C. A. Thomas, president of Monsanto Chemical Company, who delivered this year's Steinmetz Memorial Lecture

Future AIEE Meetings

Petroleum Technical Conference
Tulsa, Okla.
September 27–29, 1954
(Final date for submitting papers—closed)

Middle Eastern District Meeting
Abraham Lincoln Hotel, Reading, Pa.
October 5–7, 1954
(Final date for submitting papers—July 7)

Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 11–15, 1954
(Final date for submitting papers—closed)

Machine Tool Conference
Hotel Statler, Detroit, Mich.
October 25–27, 1954
(Final date for submitting papers—closed)

Southern Textile Conference
Raleigh, N. C.
November 4–5, 1954
(Final date for submitting papers—August 4)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 31–February 4, 1955
(Final date for submitting papers—October 20)

Southern District Meeting
St. Petersburg, Fla.
April 13–15, 1955
(Final date for submitting papers—March 29)

1955 Summer General Meeting
New Ocean House, Swampscott, Mass.
June 27–July 1, 1955
(Final date for submitting papers—March 29)

Research and Engineering—The Problem of Transition. The problem of transition from research to engineering development and a final product was presented from four points of view in a well-rounded symposium with Dr. C. R. Burrows presiding.

The point of view of sponsored research in the university laboratory was presented by A. F. Sise of MIT, where the primary purpose is "The education of men, advancement of knowledge, and service to industry and the nation." In this type of research, results rarely go beyond a working model and the information is made available to industry through the medium of publication.

The point of view of the independent research laboratory was presented by A. Latham, Jr., of Arthur D. Little, Inc. In this type of research, projects must be of immediate use to clients and bills are rendered each month. Mr. Latham pointed out, as one of the difficulties, the great reluctance of scientists to use the services of engineers—which he illustrated by practical problems. In this type of work, steering committees have been organized to advantage to hear the project leader report on results of work and then suggest to him the course of future work for the following few weeks.

Research from the point of view of "The

D. E. Garr, General Electric Company, (right) as general chairman for the North Eastern District Meeting, discusses meeting plans with Elgin B. Robertson

Government Laboratory" was presented by D. E. Marlowe of the U. S. Naval Ordnance Laboratory where the problems of mass production of expendable goods such as fuses, shells, and bombs make the problem quite different. These are long-term projects with 300 projects under way at one time and a phase development schedule is employed. There must be an extensive series of tests during the development stage before the material is ready for mass production and a great deal of effort must be put into the design disclosure.

Research from the point of view of the industrial laboratory was presented by V. H. Fraenkel of the General Electric Company who drew a distinction between small and large organizations. In the small organization, technical people are intimately familiar with the company's activities; whereas in the large integrated organization of a decentralized character, the lack of transition of concepts and ideas can slow up progress if steps are not taken towards this transition. Foresight on the part of management and stockholders is also required for projects with a long-time constant.

Timely sessions were also held on the subjects of magnetic amplifiers, feedback control systems, and the use of computers in engineering analysis.

Power Generation. Four papers were presented in a session on power generation with G. K. Kallenbach presiding. The electrical features of the new Albany steam station, which by the end of the summer will have added the last of four 102,000-kw units to the system, was described by J. M. Geiger of the Niagara Mohawk Power Corporation. Another paper, by J. L. Harvey of the same company, described an automatic hydroelectric development consisting of a 30,000-kw unit at Stewart Bridge which is remotely controlled from Spear Falls by carrier current employing frequencies in pairs known as the frequency shift principle. In still another paper by J. B. Tice and M. Temoshok, the advantages of motor-driven exciter sets for power stations was set forth.

Great interest was evoked by a paper, "Steam Turbine-Generators of the Future," presented by R. S. Neblett of the General Electric Company. The author reviewed the improvements made in turbine-generator units over the past 20 years brought about by new materials and improved design techniques up to and including the units for supercritical steam pressures 1,150 F with two resuperheats. In the light of the rate of past gains and of improved cooling methods, the hindsights were projected into the future.

Power Systems and Service Continuity. The subject of service continuity on power systems was presented in a symposium from five points of view with Vice-President G. D. Floyd presiding. The first paper, by Mr. Floyd and C. B. Kelley, outlined the problem. The point of view of the power system as a whole was presented by M. H. Mackenzie of The Hydro-Electric Power Commission of Ontario, who discussed the amount of spinning reserve and criteria for stability to maintain service continuity. The third paper dealt with the power and energy production from the aspect of the theory of probability and was presented by C. W. Watchorn of the Pennsylvania Water and Power Company. From the standpoint of the distribution systems, G. G. Auer of the General Electric Company discussed the proper application of fuse cutouts and automatic circuit reclosers to attain the degree of reliability desired. The last paper presented concerned the transmission and transformation part of the system by O. A. Starcke of the Kansas City Power and Light Company. In the presentation consideration was given to the economics of the problem and a knowledge of methods for improving service continuity as well as to some means for quantitative measurement of the effectiveness of each improvement.

Nucleonics Conferences. To complete the picture for the power people, 12 papers on nucleonics were presented in two sessions, several of which dealt with reactors. A paper on the control of nuclear reactors was presented by J. L. Owens and J. H. Pigott of the General Electric Company. The authors considered the problem from the aspect of safety for personnel and the surrounding countryside in the extreme case of reactor core disintegration. In another paper, the important factors in consideration of the use of several different types of coolants for nuclear reactors were presented by Dr. E. A. Luebke of the General Electric Company. A very interesting paper on the economics of nuclear energy in the future was presented by J. K. Pickard, formerly of the Atomic Energy Commission, entitled "The Size of the Atomic Energy Gamble." Attention was drawn to the expenditure of nearly $200,000,000 by the Atomic Energy Commission on the reactor program and the sums to be spent in the future based on MIT study costs of 4 to 7 mills per kilowatt-hour and a nation-wide average of 7.4 mills per kilowatt-hour today and, considering that these costs may go down in the future, he predicted that the first nuclear power plants would appear about 1965 and by the year 1985 only about 15 per cent of the total power generated might be from nuclear sources.

Industrial Power Systems. In a session on industrial power systems with O. T. Zittel presiding, four papers were presented. Considerable interest was shown in the description of the expanded and modernized industrial power system of the Eastman Kodak Company at Kodak Park. Present power requirements are approximately 45,000 kva designed for a high degree of continuity of service and safety and operating in parallel with the utility system through a closed tie. Approximately 95 per cent of the power is generated in the Kodak Park steam plant and the remaining 5 per cent is purchased.

Detailed comparative studies of the cost of a 480Y/277-volt system versus 208Y/120-volt system for the telephone building at Menands, N. Y., were reported by D. S. Brereton and H. D. Donnelly. The studies indicated savings of $23.5 per kva in favor of the 480Y/277-volt system with 24-volt switching in comparison with the 208Y/120-volt system and savings of over $50 per kva when compared with the 208Y/120-volt system with 120-volt switching. In another paper which dealt with the electric power distribution for the Norton Company Grinding Machine Division by Paul Russell of the General Electric Company, savings of $11.92 per kva were reported in favor of a 480Y/277-volt system compared with a 480-volt distribution system with 208Y/120 lighting.

Other Industrial Sessions. In a session on control and industrial applications, automation came into focus in connection with heavy material handling equipment and also with automatic log-handling cranes. Controlled tension by eddy current as well as d-c systems for tension control were also discussed.

The sessions of the textile conference were held on May 7 in both the morning and afternoon. Papers were presented on finishing ranges for carpets and electric heating in textile finishing, as well as a report on National Electrical Manufacturers Association and textile subcommittee co-operation for control enclosures for textiles. The afternoon session concluded with a panel discussion on carpet and felt loom drives and drive requirements.

THE SMOKER

The smoker was held at the Edison Club on Wednesday evening. After the cocktail hour and dinner, the audience was entertained by Dr. Murray Banks noted psychologist, whose subject was "Just in Case You Think You're Normal."

INSPECTION TRIPS

During the meeting, inspection trips were taken to the Turbine Manufacturing Building of the General Electric Company and the Research Laboratory and the Albany Steam Station of the Niagara Mohawk Power Corporation, all of which proved popular.

BUFFET SUPPER

The buffet supper was held in the Mess Hall at Union College on Thursday evening. Following the supper, Toastmaster Dr. Carter Davidson briefly commented on the many activities of Dr. Charles P. Steinmetz and introduced the first speaker.

The trends in District 1 were outlined by Vice-President W. Scott Hill who pointed out that the Institute now is about three times as large with over 47,000 members as it was in 1901 when Dr. Steinmetz was president. The Schenectady Section was organized in 1903; with the installation of the New Hampshire Section this year which became the 100th Section there are 13 Sections in the District and six Subsections. Mr. Hill pointed out that the Institute is somewhat unhappy about the student enrollment in the colleges, but that the matter is under study and plans are being laid for the future. In conclusion, L. A. Umansky was complimented for having arranged a timely program for the meeting which included not only sessions on power but nucleonics, semiconductors, and feedback control systems, most of which are new. Institute operation was likened to a massive educational move.

President Robertson was introduced by H. A. Winne, vice-president of the General Electric Company, retired, who presented him with a momento, a large framed picture of an AIEE group in Building 16 when Charles P. Steinmetz was president. The group was on its way from New York City to the 18th national convention in Buffalo, N. Y., and stopped off for an inspection trip and luncheon at the Schenectady works.

President Robertson commented on Institute activities and reported that the financial situation is satisfactory and that the budget is not set up with a view toward increasing the reserve.

Mr. Robertson called attention to the inadequacy of the present Engineering Societies Building and reported on the meeting in Chicago in April to which the presidents of the Founder Societies and the American Institute of Chemical Engineers were invited to inspect proposed building sites. Out of the meeting came the creation of a committee of five to make recommendations to their Boards of Directors on a location to house the engineering societies of the United States.

In respect to the matter of unity, President Robertson urged that restraint and good judgment should be exercised. He referred to his message on unity published in the April issue (*EE, Apr '54, pp 299–300*). The Board of Directors acted on the matter last January and requested Engineers Joint Council (EJC) to take steps immediately toward the development of a unity organization based upon individual membership. EJC thought enough of the recommendation to appoint its executive committee to study the matter. Again in April, the Board of Directors informed EJC that what had been done was not sufficient and EJC was requested to study the proposal of the General Electric Engineers Association (*EE, Apr '53, pp 349–51*) because the proposal was believed to have merit and came the nearest to the wishes of the members.

In conclusion President Robertson explained that the problem of unity is one of human relations. The problem of unity is complex and if six different people are asked for a definition one receives six different answers. Too many who want unity are unwilling to work for it, and Mr. Robertson raised the question of willingness to give the matter the same effort and thinking as one would about his investments and money. If there is to be unity, he said, everyone must carry the burden.

STEINMETZ MEMORIAL LECTURE

Following the buffet supper, members adjourned to the Union College Memorial Chapel where the 26th Steinmetz Memorial Lecture was given by Dr. Charles Allen Thomas, president, Monsanto Chemical Company. The lecture was on "Science, Progress and the Human Mind," and will be published in a subsequent issue of *Electrical Engineering*. The speaker was introduced by C. C. Herskind, chairman of the Schenectady Section.

COMMITTEES

Members of the General Advisory Committee for the North Eastern District Meetings were as follows: D. E. Garr, general chairman; W. Scott Hill, vice-chairman; G. J. Crowdes, secretary; W. A. Hunter, treasurer; E. S. Lee and P. L. Alger, counselors; L. T. Rader, C. C. Herskind, R. K. Fairley, H. C. Anderson, L. F. Lewis, and D. S. Brereton.

The chairmen of committees who made the arrangements were as follows: R. Cutts, Jr., finance; L. A. Umansky, technical programs; A. K. Raney, publicity; Owen G. Owens, student activities; R. W. McFall, hotel arrangements; K. K. Bowman, registration; J. C. White, smoker and social hour; B. R. Shepard, printing and tickets; E. W. Hutton, banquet; W. R. Kettenring, trips and transportation; and Mrs. W. C. White, who was in charge of the ladies' program.

Cornell University Students Win Prizes for Branch Papers

The Student Branch Paper Prize Contest was held on Friday morning, May 7, in the Hotel Van Curler. Seven papers were well presented and the authors answered questions raised by the large audience. The chairman was George F. Steeg of Rensselaer Polytechnic Institute. The papers which were presented during the contest were as follows:

1. "Construction and Design of a 12-Inch Oscilloscope From War Surplus Parts." George Biscoe, Union College
2. "Electrical Transducers and Industrial Measurement." Richard H. Cerni, Northeastern University
3. "The Synthesis of 2-Terminal Resistance and Capacitance Impedances." John F. Wilson, Yale University
4. "Repetitive Use of Information Stored in Magnetic Core Memories." George T. Kraemer, Cornell University
5. "Variable Reactance Speed Control for an A-C Crane-Hoist Drive." Charles E. Colbert, Cornell University
6. "Reduction of Phase Shifts in Audio Output Transformers." William Peil, Syracuse University
7. "A Brain Wave Evaluator." Walter J. Kirk, Worcester Polytechnic Institute

At the conclusion of the presentations, the decisions of the judges were announced and President Robertson presented the prizes. Charles E. Colbert of Cornell University won the District prize for a Branch paper which included a trip with expenses paid to the Summer and Pacific General Meeting in Los Angeles, Calif. Second prize was also won by a Cornell student, George T. Kraemer. Third prize went to William Peil of Syracuse University.

While the judges were evaluating the papers, Secretary N. S. Hibshman talked to the students on the AIEE as a world-wide organization and he described the many ac-

Authors of prize-winning Student Branch papers with Elgin B. Robertson. Left to right: William Peil, President Robertson, C. E. Colbert, and G. T. Kraemer

tivities of the Institute. The work is done by the members and values in return come in proportion to the services rendered. If efficiency is the ratio of accomplishment to effort, there is no need to conserve manpower. As many students as possible should take part in these activities.

CHAIRMEN'S AND STUDENT COUNSELORS' LUNCHEON

A luncheon meeting of student chairmen and counselors was held on Friday and provided an excellent opportunity for exchange of information on the operation of the Student Branches within the District. A cordial welcome was extended by D. E. Garr, general chairman, who said that the success of the meeting was due to the efforts of many people, and the monitors from Union College and Rensselaer Polytechnic Institute were complimented on having done a splendid job.

President Elgin B. Robertson spoke briefly to the students and explained that if the counselors and Vice-Presidents did not feel concerned about the Student Branches, then no one would be concerned about their operation.

A cordial invitation was extended by C. N. Hoyler of the Radio Corporation of America to the winners of the Student Branch Paper Prize Contest to visit New York and watch the "Mr. Peepers" program in the RCA Building, followed by a visit to the RCA Laboratories at Princeton, N. J. The objective of the trip is to get an over-all impression of the atmosphere of a laboratory and it does not matter whether the student is interested in power or electronics as the same principles apply. Mr. Hoyler welcomed the opportunity to congratulate the winners and attend the luncheon.

The results of a survey of the Branches in the North Eastern District to which 13 colleges replied were summarized by Professor Owen G. Owens, chairman of the District Committee on Student Activities. The results showed a decided trend toward increases in student enrollment in the District. Ways to stimulate interest in the Branches, Section co-operation, and methods of solicitation of student papers were considered. Five of the Branches reported that they were unable to hold student paper competitions, with several of the schools reporting the lack of competition as due to the large degree of military activities. The matter was discussed with the counselors at the smoker held on the previous evening.

Professor M. G. Malti, counselor at Cornell University, reported that the Cornell Branch was fortunate in its proximity to the Ithaca Section. In the matter of elections, they try to be as democratic as possible but if the matter is left entirely to the students they would probably elect the most popular student as chairman. This would be unfortunate as the most popular men are usually in many campus activities and therefore cannot thoroughly devote their time to the Branch work. Therefore the counselor and members of the faculty suggest a chairman and others to work with him. A slate is made up and an election is held. Professor Malti emphasized the importance of the counselors' work. Professor Owens reported that at Union they start their membership drive at the Freshman Smoker, where a table is set up with photographs about the AIEE. The year started off with a large number of freshmen and a list of jobs is maintained with a call for volunteers. Publicity is described as one of the most important jobs.

Another Branch reported holding their membership drive in the spring for the following fall. Dues are collected and held over. Professor Owens advocated organizing the membership committee in the spring.

R. R. Shank, counselor at Yale University, reported that half of the officers are elected and the other half appointed. There is a representative in each class who sees all the people in that class and the counselor is on the executive committee of the Section. Twenty-six meetings are held during the year and the students offer Dunham Laboratory to the Section for its meetings and the Section in turn includes the students on its mailing list.

J. B. Hraba of New Hampshire University also agreed that elections on the democratic basis did not work well. Juniors and seniors are required to join the AIEE or the Institute of Radio Engineers. They work closely with the Section and the counselor acts as chairman of the Student Activities Committee. Both the members of the faculty and the counselor must encourage the writing of papers.

Professor Malti extended an invitation to hold the next Student Branch meeting at Cornell University when the school holds its engineering show in the spring. The electrical, mechanical, civil, and chemical engineering students prepare exhibits, some of which are original and others which are lent by companies. The counselors voted to hold the next Student Branch meeting at Cornell University the last week in April.

The counselors elected Professor M. G. Malti as chairman of the District Committee on Student Activities for the year 1954–55. It also was voted that the outgoing chairman of the District Committee on Student Activities attend the Summer and Pacific General Meeting in Los Angeles.

Northern Textile Conference Held During North Eastern District Meeting

The Textile Subcommittee of the AIEE Committee on General Industry Applications and the AIEE Schenectady Section held a very successful conference at Schenectady, N. Y., on May 7, 1954. The conference was held in the Van Curler Hotel on the last day of the North Eastern District Meeting.

The subject of "Automation of Carpet Finishing" was presented in two parts. The first dealt with the range components and functions and was given by L. A. Runton, Alexander Smith, Inc.; the second part considered electric equipment selection and was presented by F. D. Snyder, Westinghouse Electric Corporation. This paper was a very complete presentation of the design and development details associated with the building and electrification of a completely automatic finishing range for carpets. Methods of operation, arrangement of components, and selection of motors and controls were all carefully explained. Questions from the audience indicated the extreme interest in the subject.

The paper on "Electric Heating in Textile Finishing" dealt in particular with the use of electric heat in the finishing of nylon fabrics. In his presentation, John McCreary, McCreary Machine Works, emphasized the importance of time, temperature, and tension in obtaining the proper finish of a nylon fabric.

G. E. Schulz, Nye-Wait Company, Inc., was the speaker at the luncheon session. This company manufactures high-quality carpets on a custom order basis. Mr. Schulz's subject was concerned primarily with the help the electrical engineer is giving to improve carpet manufacture processes and also the basic economic conditions of the industry in general.

In the afternoon session, L. A. Runton presided over a panel discussion on "Carpet and Felt Loom Drives and Requirements." By having each of the panel members give a short talk on his particular phase of the subject, a lively discussion ensued.

The subject of textile-type enclosures also was touched on and a short description was given of what had been done by the joint AIEE–National Electrical Manufacturers Association group as well as the new textile standards in prospect.

Fifth National Symposium Held on Electronic Components and Materials

The fifth symposium in the series of national meetings on electronic components and materials was held in the Department of the Interior Auditorium, Washington, D.C., May 4–6, 1954. Sponsored jointly by AIEE, Institute of Radio Engineers, Radio-Electronics-Television Manufacturers Association, and the West Coast Electronic Manufacturers Association, with participation by agencies of the Department of Defense and the National Bureau of Standards, the symposium was attended by more than 1,100 engineers and equipment designers from all parts of the United States and Canada.

Five general papers were given at the opening session and 36 papers were presented at the six technical sessions. Shortened versions of the technical papers were read and

discussed with a general question–answer period for all the papers following the final session.

"The Executive Views Components" was the subject of the opening session at which M. B. Carlton, chairman of the Symposium Steering Committee, outlined the scope of the subjects to be covered. W. H. Martin, Assistant Secretary of Defense (Applications Engineering), welcomed the gathering in place of Assistant Secretary of Defense D. A. Quarles, who was unable to attend.

The first speaker was Brigadier General W. Preston Corderman of the Signal Corps, U.S. Army, whose subject was "Electronics—A Vital Part of Our Defense." The advent of new weapons has created a "new look" in military strategy and tactics and the role of electronics now is not limited to communications. There now are missile guidance and control systems; electronic fuzes; guns aimed and fired by electronic means; electronic systems for ground control of interceptor aircraft; radars and computers for locating enemy guns and mortars, etc. Electronics has become the eyes, ears, nerves, and, to a certain extent, the brains which control the disposition and employment of military forces and weapons.

Increased demands are being made on the components which make up the electronic assemblies and in order for these demands to be met, a continuing program of research is necessary, not only for the military but also for industry.

Another of the interesting papers presented at the session was a survey of European component development given by R. S. H. Hylkema, Philips Industries, Eindhoven, Holland. The quantities of products are greater in the United States and while there is less standardization in Europe than here, there is a movement afoot to get more manufacturers to observe standards. The wage scale is also greater in this country: $1.68 per hour as against 72 cents, but this is on the rise there. An increase in the price of European components is indicated although now they are cheaper than here.

The first technical paper of the second session was given by J. C. Souter, Western Electric Company, and covered synthetic resins used as coatings and castings for military and telephone applications. The use of printed wiring, plastic development, and encasement was discussed.

The evaluation of moisture and fungus treatment of completely assembled equipment was considered by C. P. Lascaro of Fort Monmouth. Tests were made on treated and untreated chokes, tube sockets, capacitators, etc., under various conditions of humidity and fungus culture. Although treatment provided protection in some cases, the electrical improvement was never enough to cause any parts to pass specification requirements. It is difficult to evaluate tests which are continuing.

S. M. Arnold, Bell Telephone Laboratories, discussed the nature and growth of metal whiskers, which have caused operational failure of communication equipment. Efforts are being made to establish growth mechanism as well as to develop methods of prevention on new equipment and of treatment of equipment in the field.

Two papers were presented on barium titanate. The first by J. P. Remeika dealt with the growth of single crystals for storage

Among participants in the Electronics Components Symposium were, left to right: M. Barry Carlton, R. S. H. Hylkema, R. C. Sprague, Brigadier General W. Preston Corderman, Dr. D. E. Noble, C. H. Elmendorf, A. W. Rogers, and W. H. Martin, Deputy Assistant Secretary of Defense (Applications)

elements and the method of etching, orienting, and electroding them. The second paper by H. I. Oshry dealt with the control of the raw material, the processing and additions to barium titanate which have made possible a ceramic for capacitors of controlled domain size which keeps the high permittivity of normal barium titanate, but reduces the nonlinear properties to low proportions. A ceramic has been developed which is stable with respect to variations in temperature, voltage, and time.

The third session over which R. F. Shea, General Electric Company, presided had six papers on solid-state devices and companion components. The first paper discussed the p-n-p junction phototransistor with its electrical and optical operating characteristics and with its practical production tolerances.

The next paper was on the double-based diode which has a negative input resistance and can be used for switching applications and computer-type circuitry. Because of its potential power capabilities it may be possible to use this device as a low-voltage high-power relay or "thyratron."

Two types of rectifiers were described in the next two papers. The first, by Kashman, was about high-temperature selenium rectifiers and the second by T. S. Shilliday and C. S. Peet was on the electrical properties of titanium dioxide rectifiers.

The number of transistors used in hearing aids has now reached such proportions that data on their reliability and service performance can be trusted. This phase of quantity-produced transistors for low-power audio applications was told by F. M. Dukat.

J. Dalfonso, P. R. Mallory and Company, in the last paper of the session, discussed the advantages of the mercury battery as a power supply for hearing aids and small paging devices.

"New Frontiers in Component Development" was the subject of the afternoon and evening sessions. Two papers were given on evaporated metal film resistors, their temperature characteristics being such that their use is indicated in guided missiles, radar, and other electronic devices.

The Mellon optical storage system was described in a paper by A. Milch, of the Mellon Institute of Industrial Research. This is a vacuum-tube storage device containing a phosphor anode and a cesium photocathode. When this tube is placed in series with a d-c power source, it can be made to switch on and off solely by light pulses. The state of storage may be sensed either by the voltage drop across a series resistor or by the visible output of the phosphor.

Typical of the components based on ferrite materials is the 0.1-microsecond pulse transformer in which the fast response time and high effective pulse permeability of manganese zinc ferrite toroids permit improved component designs for digital computer circuitry, blocking oscillators, etc. The high initial permeability of this material has led to the development of low- and moderate-power frequency inductors with inductance values as high as 5 henrys per cubic inch. These were described by D. Peck, N. Cushman, and M. Geroulo.

Among other novel developments were broad-band waveguides recently developed, these being designated as "single ridge" and "flat." Two frequency ranges are covered (3.75–15 and 10–40 kilomegacycles) and are intended to replace for certain applications seven of the present standard rectangular waveguides that cover this whole frequency range.

Components for a 2,000-mc oscillator and amplifier were described by N. E. Colby of the Radio Corporation of America. Such a device was constructed using the cavities in conjunction with *2C39A* planar triodes. Since the dimensions of the cavities are more or less independent of the tube capacitance, more than one tube can be put in a single cavity and this provides a means of coupling tubes with an easily tuned single resonant circuit. This method of coupling was used

to build a 3-tube structure consisting of an oscillator, mixer, and an amplifier for use in a 2,000-mc transmitter.

The sixth session's subject was "Component Requirements for Computers, Guided Missiles, and Other New Applications." I. L. Auerbach, Burroughs Corporation, described a bistable magnetic core, called a "bimag," which is an electronic element that has made possible a reduction in size and weight of many parts of information processing systems. The bistable characteristics of the new magnetic core have made possible a new type of circuitry. Inherently these bimags provide storage of information.

"Automation: Its Impact on Components" was the subject of the final session of the symposium. L. K. Lee, Stanford Research Institute, gave a report of a 5-year program of automation production of military electronic equipment, this being divided into fabrication, process, and a study of the machines used with an evaluation of the related production techniques. Use was made of a hypothetical production line to find all the defects inherent in any of the three divisions mentioned. The production line has to be flexible for the handling of different types of work, to make different components or parts, and it must consist of versatile machine tools. One important fact was found: the effect of an automatic production line calls for closer co-operation among the engineers, designers, and the workers than heretofore.

J. W. Brush of the Bureau of Ships, U.S. Navy, told how reliability had been achieved by the use of functional subassemblies as standard building blocks, and their automatic production. A. A. Lawson of Melpar, Inc., described the wafer assembly technique and how as many components as possible which are manufactured on the outside are used in this technique.

Following this session a general question and answer period was held.

The proceedings of the symposium will be published about August 1, 1954. Orders for copies at $4.50 each up to August 1, should be sent to A. E. Zdobysz, Room 206, 1 Thomas Circle, Washington 5, D.C. After August 1, orders should be sent to AIEE Order Department, 33 West 39th Street, New York 18, N.Y.

M. B. Carlton was chairman of the Steering Committee and the chairmen of the other committees were as follows: A. W. Rogers, technical program; K. A. H. Smith and W. J. Ellenberger, co-chairmen of local arrangements; A. E. Zdobysz, finance; P. H. Cousins, publicity; and A. E. Javitz, proceedings publication.

W. L. Cisler, Detroit Edison Company, describes a proposed arrangement for a steam plant utilizing nuclear energy. Looking on are, left to right: S. R. Sapirie, Atomic Energy Commission; Dr. Alvin Weinberg, Oak Ridge National Laboratory; W. H. Lee, vice-chairman, Oak Ridge Section; D. M. Clarke, assistant secretary-treasurer; R. B. Somers, chairman; E. A. Crowe, secretary-treasurer; D. B. Janney, director; and D. W. Cardwell, a member of the AIEE Committee on Nucleonics

Walker Cisler Addresses Oak Ridge Section Meeting

On May 13, 1954, the AIEE Oak Ridge Section held what it describes as its most outstanding meeting since it was established in February 1950. The principal speaker was Walker L. Cisler, president and director of The Detroit Edison Company, who spoke on "A Look at Atomic Power." R. B. Somers, chairman of the Section, also introduced two special guests: S. R. Sapirie, manager of the Atomic Energy Commission's Oak Ridge operations, and Dr. Alvin Weinberg, director of research at the Oak Ridge National Laboratory.

Mr. Sapirie cited the electrical engineering profession and the electrical industry as of prime importance to the Atomic Energy Commission. The Commission, he told the group, will be dependent on the power industry for 50 billion kilowatt-hours per year after the present expansion, an amount totaling "more than the consumption of the entire country of Canada." He spoke of Mr. Cisler as "an old friend of Oak Ridge operations," and referred to a time in 1950 when the two major plants, the *K-29* and *K-31*, were brought into production. Tennessee Valley Authority power stations at that time were unable to supply the local demand, so Mr. Cisler was called on to help. Through his efforts, power authorities from all over the country were contacted, who in turn arranged for electricity from throughout the Midwest to be channeled into Oak Ridge as needed.

Dr. Weinberg called Mr. Cisler a "fast reactor protagonist coming into homogeneous territory," and praised him for his "drive in making nuclear energy a real business."

Mr. Cisler, in speaking to the more than 300 members and guests of the Oak Ridge Section present, stated that atomic power as a national utility will arrive gradually, to supplement and not to supplant present power facilities. He listed the three main questions to be solved in the development of atomic power on a commercial basis: 1. How must we go about fitting atomic energy into our national economy? 2. How do we go about making this meet the competitive aspects of present fuels? 3. The conservation of atomic energy.

"Most of our present great expenditures in the field of atomic energy," he stated, "are because of the military aspects of the problem. First atomic energy must become part of our present structure, and not be a drain on our economy."

The greatest immediate needs for atomic power, he claimed, are not in the United States, but in other countries where natural resources have not been developed and refined. He defined the present facilities for power production in the United States, and told of the increasingly efficient plants now being developed, in which cost of electrical production is constantly being reduced. But first, before atomic power can become an economic reality, Mr. Cisler stated, the present Atomic Energy Act must be revised to make room for free enterprise on a competitive level giving equal opportunity to all qualified companies for developing it.

The actualities of full-scale atomic power, he concluded, are still far in the future, but "the rewards will be great—in having one of the most valuable means for keeping the nations closer together, on a friendly basis."

Ridgway Section Names Winner of Engineering Scholarship

The AIEE Ridgway (Pa.) Section has awarded the 1954 Elk County Engineering Scholarship to Edward Henry Stoker, St. Marys High School senior. This is the second time the scholarship has been offered. It was won in competition with students from seven other Elk County high schools.

Students who participated were selected by their principals as students qualified by their high school work for entrance into engineering and who had a specific interest in studying engineering in college. Two examinations were given to determine the student best qualified to receive the scholar-

ship. The first was a college entrance examination taken by all applicants. The second was an engineering college entrance examination to analyze the potential ability of the applicant in the field of engineering.

Selection of the winner was made by the Section's Scholarship Committee with the assistance of Professor C. H. Griffin of the Pennsylvania State College. Members of this year's committee are J. H. Schneider (chairman), C. F. McGinnis, R. F. Edwards, W. H. Austry, and Q. Graham.

The $1,200 scholarship is sponsored by the Ridgway Section but has been financed by industries and interested individuals of Elk County and the AIEE. The goal is to encourage qualified high school graduates within the county to enter the field of engineering which is now experiencing a critical manpower shortage. The scholarship is the first of its kind ever sponsored by an AIEE Section.

Philadelphia Section Celebrates Birthday of Mark I Calculator

A large and appreciative audience helped to celebrate the tenth anniversary of the completion of the Harvard Mark I Calculator by attending the April 12 dinner and meeting arranged by the AIEE Philadelphia Section. The guest of honor was Dr. Howard Aiken, director of the Harvard Computation Laboratory and "father" of Mark I. With him were three of his Mark I associates at Harvard, Richard Bloch, now with Raytheon Manufacturing Company, R. V. D. Campbell, now at the Burroughs Research Center, and Dr. Grace M. Hopper, Remington Rand, Inc. Moderator of the discussion at the meeting was Dr. C. V. L. Smith, co-ordinator for computers and electronic systems for the Office of Naval Research.

At the meeting, whose title was "Computers Yesterday and Tomorrow—A Celebration of 10 Years of Progress," each of the former Mark I staff members helped to celebrate the past 10 years of progress by highlighting one aspect of what the next decade holds in store for the computer art.

Dr. Aiken stated that much remains to be done in perfecting electronic computing machines, and indicated areas in which progress could be expected, specifically, new logics for computers specifically designed for jobs in business and industry, improvements in the theory of discrete-variable circuits, and improvements in system reliability resulting from the wise use of new components. Dr. Aiken characterized the major contribution of the electronic computer to modern life as the "elimination of mental drudgery." Computers will not replace thinkers; instead, they will free the mind from logical routines so that men may once again have time to think.

Mr. Bloch expressed the opinion that the next decade would see a growth of large-scale electronic data-handling systems for business and financial use which would rival the growth of scientific computers during the last decade. He emphasized that there is no reason to expect that systems designed for business purposes would follow closely the patterns and logic of machines designed for scientific computation.

Mr. Campbell reminded the audience that significant trends toward decentralization exist in industry, and indicated that electronic equipments might play a significant role in smaller decentralized organizations as well as in mammoth centralized ones.

Dr. Hopper echoed Dr. Aiken's point of view by stating that machines are dumb, and must be led by the hand. The next generation of programmers must teach machines how to make use of the limited intelligence they process. The most promising approach for the future appears to lead to computers which are able to make their own detailed program from exceedingly brief instructions given to the machine by the human operator, thus relieving the programmer from the most boring, time-consuming, and error-producing part of his present job.

Considerable discussion was generated by the four talks. Dr. John Mauchly of Remington Rand pointed out that machines might take over certain other aspects of thinking than the logical ones if they were designed to do so. Existing machines were designed to be ruthlessly logical, with no trace of inventiveness or originality, but modern statistical techniques may offer a clue as to how to build controlled originality into a computing machine.

Appliance Standards and Tests Stressed at AIEE Conference

Some 220 engineers from the appliance industry attended the Technical Conference on Domestic Appliances at the Morrison Hotel, Chicago, Ill., May 17–19, which was sponsored by the AIEE Committee on Domestic and Commercial Applications and the Chicago Section. The theme was "Performance Testing and Standardization" and the program was directed toward all the interests in the appliance industry: manufacturing, consumer, utilities, and approvals laboratories. Registrants included representatives from a number of utilities and approvals laboratories, together with representatives of 50 manufacturers.

J. C. Sharp, Hotpoint Company, in his keynote address said that appliance products must be engineered "to protect the name of the product and protect the technically unsophisticated customer." Papers by approval and independent laboratories carried out the same theme. F. J. Schlink, Consumer's Research, Inc., considered "... reasonable safety to be important above all ..." while H. C. Koenig, Electrical Testing Laboratories, Inc., stated that "the electric appliance industry is woefully in need of performance requirements for effectiveness, safety, and endurance." A paper by R. C. Bryce and Frank Cohn of the Philadelphia Electric Company emphasized the importance of extremely low leakage current standards based on physiological perception rather than on danger of fatality.

W. R. Milby, Customers' Service Division, Detroit Edison Company, emphasized the service problem, by citing the 600,000 small appliances that Detroit Edison repaired last year. He pleaded for standardization across the appliance industry to reduce the costs to the ultimate consumer.

In a panel discussion presenting the user's viewpoint on appliance problems, Miss Bernice Strawn, home equipment editor, *Woman's Home Companion*, raised fundamental questions on appliance design: "Is it easy to use? Does the consumer require training? Is the job done better in a practical way?"

Representatives of several manufacturers presented papers on the testing of appliances. G. H. Bramhall, General Electric Company, presented a special testing machine for evaluating soil removal performance of vacuum cleaners. H. T. Thunander, Westinghouse Electric Corporation, presented a description of the recently developed electronic temperature control device for range surface units. F. P. Stearns, Metals and Controls Corporation, described methods and limits whereby a thermostat manufacturer may adapt himself to less certainly controlled inspection of a customer. Papers were also presented on testing of automatic blankets, refrigeration control systems, and automatic washer vibration.

Frank Spayth, P. R. Mallory Company, presented a new method of contact testing, together with statistical data on the contact sticking forces of various materials.

G. S. Jones, Jr., Air Conditioning and Refrigeration Institute, presented a paper prepared jointly with H. A. Brysselbout of the York Corporation, on the "why, when and where" of power factor correction for room air conditioners. He cited recently collected figures from the manufacturers on the average power factors of the 1-, $^3/_4$-, $^1/_2$-, and $^1/_3$-hp sizes of room air conditioners. He concluded that whatever problem exists can be solved in the next several years by the joint co-operation of manufacturers, utilities, and standards groups.

B. F. Parr, Westinghouse Electric Corporation, presented a paper on proposed standards for heating appliances, summarizing the

Representatives from industry participate in a panel discussion of appliance problems during the recent Chicago conference. Left to right: T. H. Cline, C. V. Krichton, Allen Bate, W. R. Weeks, W. E. Mahaffay, H. A. Strickland, G. S. Hill, and the moderator, Miss Bernice Strawn

standards development in the heating appliances industry over the last several years. This has anticipated submittal to National Electrical Manufacturers Association (NEMA) and American Standards Association.

Audience participation consisted primarily in affirming a need for appliance standards and questioning what organizations would be most suitable for such standards to be developed. A number of persons stated that they believed the AIEE Committee on Domestic Appliances should sponsor such standardization work, whereas manufacturers' representatives felt that the NEMA committee served this purpose historically and should be stirred into action now.

Approximately 60 attended the inspection trip to the Underwriters' Laboratories. Also, inspection trips were taken to the Range and Refrigerator plants of Hotpoint, Inc.; Dole Valve Company; Birtman Electric Company, and Sears-Roebuck Appliance Testing Laboratories.

Fall General Meeting Scheduled for October

Chicago, Ill., will be the site for the 1954 AIEE Fall General Meeting, October 11-15. Headquarters for the meeting will be the Morrison Hotel.

The technical program will give special attention to the air transportation industry with eight sessions being planned around that subject. Fifty additional sessions are also being organized in the five technical divisions of the Institute. The Power Division committees now engaged in this planning are those on Carrier Current, Insulated Conductors, Power Generation, Protective Devices, Relays, Rotating Machinery, Switchgear, System Engineering, Transformers, and Transmission and Distribution.

In the Science and Electronics Division, the Committees on Computing Devices, Electrical Techniques in Medicine and Biology, Electronics, and Nucleonics are represented. Four sessions are also scheduled by the Communications Division Committees on Communication Switching Systems, Radio Communication Systems, and Television and Aural Broadcasting.

In the Industry and General Applications Divisions the following committees will sponsor programs: Chemical, Electrochemical and Electrothermal Applications, Feedback Control Systems, General Industry Applications, Industrial Power Systems, Air Transportation, Land Transportation, and Production and Application of Light.

The members of the 1954 Fall General Meeting Committee are J. F. Calvert, chairman; F. D. Troxel, vice-chairman, F. A. Cox, secretary; M. V. Maxwell, treasurer; M. J. Adams, trips and transportation; Edward Allen, publicity; W. M. Ballenger, hotel arrangements; A. B. Bronwell, technical program; Nathan Cohn, general session; R. C. Erickson, hospitality; L. R. Janes, sales of papers; E. G. Norell, registration; Mrs. R. R. O'Conner, ladies' activities; H. B. Powers, entertainment; John Romano, smoker; E. R. Whitehead; dinner-dance; J. Woods, finance and budget.

Ridgeland Station of the Commonwealth Edison Company, newest and most modern of the 11 generating plants of the system serving Chicago and Northern Illinois, is one of a number of inspection trips scheduled for the Fall General Meeting of the AIEE

California Technology Branch Announces Officers, Paper Award

George Wada of the Joint AIEE–Institute of Radio Engineers Student Branch at the California Institute of Technology has been named winner of the Los Angeles area student prize competition of the AIEE. His subject was frequency stability measurements of high-frequency oscillators.

The Branch also announces the election of H. G. Leney and J. W. Rocchio as co-chairmen for 1954–55. T. C. Taussig is the new secretary-treasurer.

Feedback Control Applications Discussed at April Conference

Approximately 300 engineers met at the Claridge Hotel in Atlantic City, N. J., April 21–23, to participate in the Second Conference on Feedback Control Systems sponsored by the AIEE.

Dealing with applications of feedback control, an opportunity was afforded for engineers in various industries to describe and demonstrate equipment associated with feedback systems. This exchange of practical information from various viewpoints was helpful to those attending.

Two methods of presenting practical information on feedback control were used. The first method was by presentation of technical papers in which the emphasis was on applications of feedback control leading to practical equipment.

As the second method of presentation, a novel plan of scheduled demonstrations of actual equipment and components was used. Each person attending the conference was given the opportunity of selecting a number of demonstrations that he wished to attend. Since the demonstrations were presented at scheduled times, it was possible to have orderly, complete presentations followed by question and discussion periods. Many favorable comments have been received on the demonstrations and the manner in which they were presented.

The program indicated the wide range of applications of feedback control as well as the diversity of components. As boundaries between fields are crossed and the level of specialization rises, the need for a common language becomes increasingly great. For this reason, "The Language of Feedback Controls" was discussed by H. W. Cory of the Allis-Chalmers Manufacturing Company, chairman of the Feedback Control System Terminology and Nomenclature Subcommittee. He described the terminology work accomplished by professional societies in the United States and abroad.

FEATURED SPEAKERS

The conference was opened on April 21 with an address by F. E. Crever, Knolls Atomic Power Laboratory, General Electric Company. Mr. Crever, as chairman of the AIEE Committee on Feedback Control Systems, welcomed those present and cited the growth of activity and scope in feedback control systems engineering.

At the banquet, which was held on April 22, the speaker was Dr. L. N. Ridenour, International Telemeter Corporation. Dr. Ridenour, who is editor-in-chief of the Massachusetts Institute of Technology Radiation Laboratory Series, spoke of present and future problem areas and possible approaches to their solution. Presiding over the banquet program was Dr. S. W. Herwald, Air Arm Division, Westinghouse Electric Corporation, and former chairman of the AIEE Committee on Feedback Control Systems.

The conference was closed on Friday morning with an address by Dr. G. S. Brown, Massachusetts Institute of Technology. Dr. Brown, who was the first chairman of the AIEE Committee on Feedback Control Systems, spoke on "Serendipity—or How We Learned about Feedback." Serendipity, or the gift of finding valuable things not sought for, was related to the development of feedback control as a technique and as a field of professional activity. By interesting analogies, Dr. Brown applied the serendipity technique to some current challenging problems in engineering, economics, and education.

CONFERENCE SUBCOMMITTEE

The subcommittee which planned and executed the conference consisted of the following: A. C. Kegel, chairman; L. C. Harriott and H. T. Marcy, program; E. R.

Behn, scheduled demonstrations; R. M. Hutchinson, local arrangements; G. L. Stancliff, Jr., publicity; G. S. Axelby, abstracts and proceedings; R. S. Gardner, advisor.

PROCEEDINGS

Complete texts of all papers and descriptions of all scheduled demonstrations will be published in the near future. Copies of the conference proceedings may be ordered at $3.50 per copy from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

Notre Dame Engineering Students Hold Open House

Students of the college of engineering of the University of Notre Dame held their 1954 Engineering Open House, May 14 and 15. This annual event is designed to acquaint all visitors with the scope of work done in each department.

The program was highlighted by the General Electric "House of Magic Show," the annual "chariot race," and a special exhibition of a group of experimental automobiles.

Prize Papers Announced for District 4 Competition

All 18 Student Branches of District 4 participated in the Student Paper Competition held on April 21–24 at the North Carolina State College. W. M. Stevenson, Jr., is chairman of the District Committee on Student Activities.

Authors of the prize-winning student papers were as follows:

First: "The Development of Corona-Indicating Equipment and Its Use in Determining the Characteristics of Insulation," by William C. Yengst, Duke University

Second: "An Electronic Teletype Distributor," by Robert A. Moore, University of Alabama

Chinese Engineering College Needs Technical Literature

An appeal has been received by Engineers Joint Council for engineering books and literature for use by the Taiwan College of Engineering, Tainan, Taiwan (Formosa), China. The school, which is being rehabilitated through the efforts of a Purdue University group on a Foreign Operations Agency Mission to China, has need of books, periodicals, magazines, etc., on pure technology, management, and industry.

Packages under 70 pounds (book rate) may be sent directly by parcel post addressed to Professor Paul B. Eaton, FOA Mission to China, APO 63, care of Postmaster, San Francisco, Calif. If donations weigh over 70 pounds, or if donors do not wish to take care of shipping, material may be sent to the attention of Charles Merrick or William McLean at Lafayette College, Easton, Pa.

Prize Paper Authors Visit RCA

Winners of prize paper contests for college students in three eastern Districts of the AIEE on a recent visit to the David Sarnoff Research Center of the Radio Corporation of America at Princeton, N. J. Left to right: Peter Frommer, University of Cincinnati; Thomas Brady and Frederick Wilson, Manhattan College; Hirsch Mandelberg, Johns Hopkins University; William Peil, Syracuse University; and Steven Scrupski, Newark College of Engineering, examine a laboratory model of a transistorized portable radio receiver against a background of early television pickup and picture tubes

Milwaukee Section Prize Papers

Shown during the recent Student Paper Competition sponsored by the AIEE Milwaukee Section are, left to right: Erich Sobota, Wisconsin Electric Power Company, judge; Gordon Clothier, Allis-Chalmers Manufacturing Company, judge; John St. John, Milwaukee School of Engineering, first prize, "A Production Method of Metallurgical Analysis"; Wilfred Lepeska, Marquette University, third prize, "The Transistor"; Don Johnson, Michigan College of Mining and Technology, second prize, "Operation of Fluorescent Lighting Equipment"; and William Elliot, Cutler-Hammer, Inc., judge

District 2 Prize Paper Competition

Contestants, judges, and official guests shown at the AIEE District 2 Prize Paper Competition held at the University of Cincinnati on April 30 and May 1. Front row, left to right: Donald Corbitt, University of Akron; Frederick Clarke, U. S. Naval Academy; Hirsch Mandelberg, Johns Hopkins University; Andrew Revay, University of Pittsburgh. Second row: Peter Frommer, University of Cincinnati; Ralph Sinnott, Villanova University; Walter Morgan, Carnegie Institute of Technology; Maximillian Kraft, Drexel Institute of Technology; Stanley Weingart, Case Institute of Technology. Third row; Professor John Artley, Johns Hopkins University; Professor H. G. Howard, U. S. Naval Academy; Professor Albert Herweh, University of Cincinnati; Professor Ernest Welch, Howard University; Walter Morton, Vice-President, District 2. Fourth row: John Quitter, judge; Herbert Fuldner, chairman, University of Cincinnati Student Branch; Sheldon Storer, judge; Carl Evert, Student Branch advisor; Leon Nonemaker, secretary, District 2. Winners of the competition were: first place—Peter Frommer, "An Electronic Blood Count Meter"; second place—Walter Morgan, "A New System for Broadcasting Binaural Sound"; third place—Hirsch Mandelberg, "A Gated Amplifier and Demodulator"

District 3 Sponsors Student Paper Contest

The Students Prize Paper Contest sponsored jointly by AIEE District 3 and the AIEE New York Section was held with the Student Branch meeting at Columbia University on May 7, 1954. Participating institutions were the College of the City of New York, Columbia University, Cooper Union, Manhattan College, Newark College of Engineering, New York University, Polytechnic Institute of Brooklyn, Pratt Institute, Rutgers University, and Stevens Institute of Technology.

Vice-President M. D. Hooven presided at the contest, for which the following winners were announced:

First: "Instruments for Direct Time-Phase Measurements," Thomas J. Brady, Manhattan College

Second: "Missionaries Versus the Cannibals," Stephen E. Scrupski, Newark College of Engineering

Third: "The Floating Grid Circuit," Frederick C. Wilson, Manhattan College

Fourth: "Design of Short-Wave Signal Generator," Ralph N. Battista, Manhattan College

Also presented were "The Design of Cable Loss Equalizer for Video Systems," by Karen N. Frederick, Newark College, and "An Experimental Method Synthesis of Nonlinear Network," by John H. Wuorinen, Columbia University.

Following the announcement of prize winners, L. R. Anderson, General Electric Company, demonstrated the light values of both incandescent and fluorescent sources in his address on "Light Sorcery."

Luncheon and cash prizes for second, third, and fourth places were donated by the New York Section; first prize by District 3.

Bound Record Available for 1953 Telemetering Conference

The complete papers and talks, with illustrations, as presented at the 1953 National Telemetering Conference held in Chicago, Ill., are now available in bound form. The 230-page book, "1953 National Telemetering Conference Record," contains 34 papers on missile and utilities telemetering and presents a large amount of up-to-the-minute material on both new fields of investigation and applications data.

Copies may be obtained for $2.00 each postpaid from Post Office Box 271, Plainville, Conn., or AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

Chicago Section Announces Student, Section Prize Papers

The AIEE Chicago Section announces the award winners in the Section's recent prize papers contests. The Student Papers Contests were under the direction of Frank Simon, chairman of the Students and Young Engineers Committee. Winners of the student competition at the Illinois Institute of Technology on April 27 were

Undergraduate

First: "Piezoelectric Ceramics in High Fidelity," Harold A. Johnson

Second: "3-Tube 220-Mc Transceiver," Richard A. Bucich

Third: "High-Frequency Performance of Transistors," Ronald A. Oeste

Honorable Mention: "Super-regenerative Receiver," Leon D. Clements

Graduate

First: "Transient Behavior of Circuits Containing Arcs Determined by the Reversion Method," Bernard Saltzberg

Second: "Analysis of a Traveling-Wave Tube With Transverse Current Components," Anthony G. Martorell

Third: "Transients in Waveguides," Henry H. Zucker

Winners of the Student Papers Contest held at Northwestern Technological Institute on April 27 were

Undergraduate

First: "Silent Sound-Ultrasonics, Today and Tomorrow," Lawrence McGrath

Second: "Instantaneous Prediction of Optimum Radio Transmission Paths," Peter Leahy

Third: "Feedback Principles Applied to Power Cranes," John Sullivan

Honorable Mention: "A Survey of Multipliers for Use in Analogue Computers," Charles Bading

Honorable Mention: "Towards a Fuller Realization of Musical Reproduction," Vito Brugliera

Graduate

First: "A New Microwave Detector," Gene Strull

Second: "Considerations in Design of Reflector Antennas at Microwave Frequencies," Florian Shnurer

Third: "Reflection of Electromagnetic Waves at Conducting Surfaces," Paul Mayes

The following awards were made to finalists in the Section's Prize Paper Contest, which was under the direction of A. M. Hopkin, acting chairman of the Prize Paper Committee.

First: "Synchronous Machine Analogues for Use With the Network Analyzer," James E. Van Ness, Northwestern University

Second: "Investigation of Humidity Characteristics of Paper Capacitors," R. M. Bergslien, Armour Research Foundation

Third: "Control of Electric Field on Bus Connectors in Circular Enclosures," A. K. Alsaker, N. Polgov, Delta-Star Electric Company

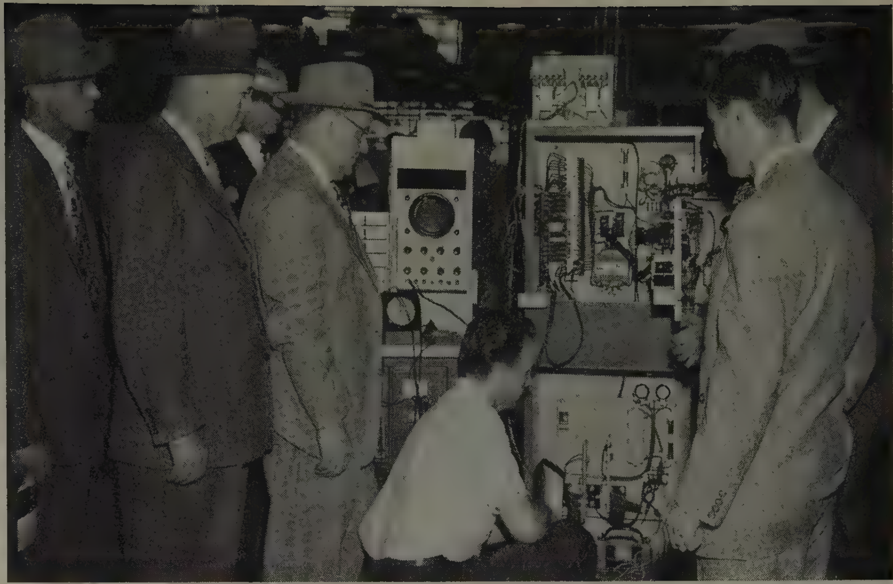
Fourth AIEE Conference on Electric Welding Held

The fourth AIEE Conference on Electric Welding was completed at Milwaukee, Wis., on May 21 when leaders in the field met at five sessions during the 3-day meeting held at the Hotel Schroeder. The conference was arranged by the AIEE Committee on Electric Welding under the chairmanship of E. J. Limpel, A. O. Smith Corporation, and was held in co-operation with the Milwaukee Section of the American Welding Society. Registration numbered 214 with the greater number of those present representing outstanding leaders in field of arc and resistance welding.

The 19 papers presented covered fields of inert gas arc, fundamental arc research, safety, instrumentation, and resistance welding. The availability of proceedings of the conference, which will include not only complete copies of the papers but also transcripts of the discussions, will be announced in *Electrical Engineering*. Orders for these may be placed with the AIEE Order Department, 33 West 39th Street, New York 18, N. Y., at $3.50 per copy. A limited number of proceedings of previous conferences held at Detroit, Mich., during 1948, 1950, and 1952 are still available.

The new bibliography on high-pressure arcs was released during the session on fundamental arc research. This publication is sponsored by the Subcommittee on Fundamental Arc Research of the AIEE Committee on Electric Welding which has been working for several years on compiling a list of all available publications on the subject. The published bibliography consists of 2,450 entries of (*a*) author's name, (*b*) title of the article, (*c*) name of the publication, (*d*) volume number and date of publication, and (*e*) number of pages of the articles; it includes not only those written in English but also many foreign publications. Copies are available from the AIEE Order Department for $1.50.

Four plant tours in the Milwaukee area were a popular attraction this year. These inspection tours covered production of equipment and principal uses of arc resistance welding equipment and controls at A. O. Smith Corporation, Cutler-Hammer, Inc., Square D Company, and Nash Motors Division of Nash Kelvinator Corporation.



C. Meyer, Square D Company, explains the testing and calibration of NEMA N2X electronic welder control to an AIEE group attending the recent Conference on Electric Welding

District 7 Student Branches Meet at Kansas State College

The District 7 Student Branch Conference was held at Kansas State College, April 23–24, 1954. Representatives from 17 schools were present at the conference and papers were presented by students from 15 schools.

The main dinner was held on Saturday, April 24, at which time B. J. George, of the Kansas City Power and Light Company, gave a talk entitled "Tomorrow's Horizons."

At the dinner three new counselors and the Vice-President of District 7 were initiated into the school's association of counselors and dignitaries of the District.

Mr. Dillingham, of the Agricultural and Mechanical College of Texas, who for over 20 years has initiated the new counselors and other distinguished visitors into this organization, was given a citation for meritorious service in this department.

The winning papers of the student paper competition were announced as follows:

First: "A Primary Standard of Time and Frequency," by John Featherston, University of New Mexico

Second: "A Vacuum-Tube Characteristic Plotter," by Robert C. Distler, St. Louis University

Third: "A Device for Splicing 16-Mm Magnetic Film," by Charles D. Cowan, Kansas State College

The judges of the student paper competition were: A. A. Dahms, Allis-Chalmers Manufacturing Company; C. F. Crandell, Southwestern Bell Telephone Company; D. Paul Hutchison, Southwestern Bell Telephone Company. These men are chairmen of the Kansas City, the North Texas, and the Wichita Sections of the AIEE, respectively.

Main banquet of the District 7 Student Branch Conference at Kansas State College

Central Indiana Section Announces Student Awards

"The Mechanical Aspects of Microwave Transmission" by Robert Carral, Purdue University, received top honors in the student technical paper competition sponsored by the AIEE Central Indiana Section.

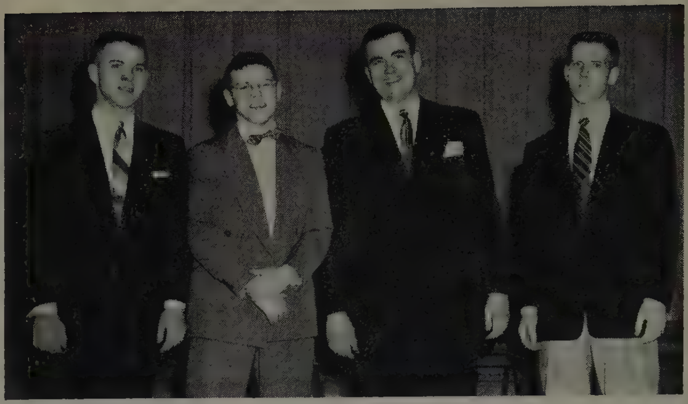
Student papers were presented before a recent joint meeting of the Section and Purdue and Rose Polytechnic Institute Student Branches at Rose Polytechnic, Terre Haute, Ind. Members of the Student Branches were guests of the Section at a dinner preceding the meeting.

Runners-up, in order, were contributions by: Erwin Ulbrich, Rose Polytechnic; Joseph Verdeyen, Rose Polytechnic; and Giles Morill, Purdue.

New chairman of the Central Indiana Section is L. H. Wollenweber, Eli Lilly and Company. His election was announced by G. R. Guthrie, past chairman, who also made known the names of the other new officers: Dr D. D. Ewing, Purdue University, first vice-chairman; T. W. Metz, Allis-Chalmers Manufacturing Company, second vice-chairman, and E. E. Sterner, Western Electric Company, secretary-treasurer.

Executive Committee members chosen for the coming year are: R. H. Whaley, Eli Lilly and Company; H. W. Hale, Purdue University; R. D. Strum, Rose Polytechnic Institute.

Successful contestants in a recent essay contest sponsored by the Central Indiana Section are, left to right: Robert Carral, Purdue University; Joseph Verdeyen and Erwin Ulbrich, Rose Polytechnic Institute; and Giles Morill, Purdue



Council of Engineering Society Secretaries Meet

The Council of Engineering Society Secretaries met in Detroit, Mich., May 20–21, 1954, with headquarters at the Engineering Society of Detroit. The AIEE was represented by Secretary N. S. Hibshman. The purpose of these meetings is for a mutual exchange of views on operational procedures and the occasion provides the only opportunity for the secretaries of national societies to get together for discussion with the secretaries of local engineering organizations.

The meeting was organized in five panels as follows:

1. Publication policies and methods.
2. Office administration.
3. Membership.
4. Intersociety relations.
5. Miscellaneous, social activities, dues, collection of dues, obtaining industrial support, and the selection of speakers and subjects, etc.

Members of the council visited the headquarters of the American Society of Tool Engineers (ASTE). Following a dinner, they enjoyed a timely address, "Atomic Preservation of Food," given by L. E. Brownell, director of the Fission Products Laboratory, University of Michigan.

In an election of officers Edward H. Robie, secretary, American Institute of Mining and Metallurgical Engineers, was elected president; J. E. Harrington, executive secretary, Western Society of Engineers, was elected vice-president; C. S. Doerr, executive secretary, The Engineers Club of Philadelphia, was elected treasurer, and M. C. Turpin, secretary. The directors are T. J. Ess, managing director, Association of Iron and Steel Engineers; Allan R. Putnam, ASTE; W. P. Youngclaus, Jr., administrative secretary, American Society of Lubricating Engineers; and Ernest Hartford, deputy secretary, The American Society of Mechanical Engineers, past-president, ex-officio.

Members of the Council of Engineering Society Secretaries with their guests at the recent meeting in Detroit

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Industry Division

Committee on Electric Heating (*Harold Bunte, Chairman; W. C. Rudd, Vice-Chairman; R. W. Kise, Secretary*). The committee held a meeting in April and great interest was shown in the main project of the committee.

Plans are being made for a Conference on Electric Heating to be held in Chicago, Ill., May 10–11, 1955, sponsored jointly by the Chicago Section and the Committee on Electric Heating.

This conference will include all of the phases of industrial applications of electric heating including furnaces, induction, dielectric, resistance, and radiation heating. There will be about 16 or 17 papers. The conference will be similar to the one held in Detroit, Mich., in May of 1953 which drew about 400 people.

The subcommittees are working, accumulating data, and following all new developments. The Induction and Dielectric Heating Subcommittee has been particularly active and has assembled a list of consultants who have indicated an interest in performing the work for Federal Communications Commission (FCC) certification in connection with industrial equipment as covered in part 18 of the FCC "Rules and Regulations." The subcommittee is also currently reviewing Proposed Standard, Test Code, and Recommended Practice for Induction and Dielectric Heating Equipment, AIEE number *54*, October 1952.

Power Division

Committee on Power Generation (*J. B. McClure, Chairman; F. L. Lawton, Vice-Chairman; J. E. Barkle, Jr., Secretary*). The Station Design Subcommittee has sponsored a session on boiler room controls. Subsequently a similar session on turbine room controls was sponsored by the Speed Governing Subcommittee. This subject of control

was well received and it is proposed that in the near future a joint report will be prepared, summarizing the current practices.

The Excitation Subcommittee is continuing, through a working group, its activities on terms and definitions for excitation systems and major components.

The Joint Subcommittee on Application of Probability Methods to Power System Problems has prepared and circulated a progress report on "Forced Outage Rates of High-Pressure Steam Turbines and Boilers," which adds another year's experience record to the already available statistics.

Committee on Transformers (*J. A. Adams, Chairman; J. R. Meador, Vice-Chairman; M. H. Pratt, Secretary*). At a meeting in Chicago, April 23, 1954, the Committee on Transformers approved a proposed Test Code for Power Factor Testing of Power Transformers and revisions to the short-circuit sections of American Standard *C57.12*. Both of these items will be sent to the AIEE Standards Committee for further action.

In order to further the investigation which is being made of switching surges and the switching surge strength of transformers insulation, it is the concensus of the committee that a study should be undertaken to try to establish a standard switching surge, such as for example was done in the case of lightning, to be used as a basis for design. Since system characteristics and other apparatus are involved, other committees are being consulted to determine whether some common investigation should be undertaken.

The committee has decided to set up a West Coast Subcommittee.

At the meeting of April 23, progress was indicated for most of the items covered in the last report of the committee (*EE, Feb '54, p 177*).

Science and Electronics Division

Committee on Instruments and Measurements (*J. G. Reid, Jr., Chairman; E. Weber, Vice-Chairman (East); W. S. Pritchett, Vice-Chairman (West); C. F. Savage, Secretary*). Recent meetings of the committee have been those at the 1953 Summer General Meeting, at AIEE Headquarters on October 7, 1953, luncheon meeting at the 1954 Winter General Meeting, and at AIEE Headquarters on May 18, 1954. A second meeting from the same May 18 agenda was held on June 24 during the Summer and Pacific General Meeting.

Much work has been done in reorganizing the Instruments and Measurements Committee into its present structure involving group subcommittees. This organizational concept was approved by the Committee on Technical Operations on January 20, 1954.

Because of the continued success of the special technical conferences with respect to the attendance and the caliber of the technical program attracted, the following have informally established themselves as regularly recurring events: Scintillation Counter Symposium (biennial), Electronics Components Symposium (annual), National Telemetering Conference (annual), Conference on High-Frequency Measurements (biennial), Conference on Recording and

Petroleum Industry Conference

A 3-day technical conference for the petroleum industry has been scheduled for Tulsa, Okla., September 27–29. About 20 papers will be on the technical program relating to electrical aspects of the petroleum industry. Held under the sponsorship of the newly formed Petroleum Industry Committee, this initial AIEE conference in the industry will be the result of the combined efforts of the Tulsa and Oklahoma City Sections. Seated are, left to right: W. F. Hilderbrand, J. H. Heller, G. R. Van Burkleo, W. H. Stueve (Oklahoma City conference chairman), R. S. Gardner. Standing, left to right: R. D. Bennett, Professor D. L. Johnson (Student Branch counselor, Oklahoma Agricultural and Mechanical College), J. D. Wells, R. J. Thompson (Oklahoma City Section chairman), V. J. Sittel (Tulsa conference vice-chairman), M. C. Callihan, H. M. Furtney (Tulsa Section chairman), D. H. Watt

Lehigh Valley Section Managers

The AIEE Lehigh Valley Section held a Board of Managers meeting on May 21, at which time the outgoing board, under retiring chairman, J. H. Black, welcomed the incoming board under the new Section chairman, D. L. Greene. Seated left to right around the outside of the table are: S. C. Townsend, Allentown Division vice-chairman; E. Scagliano, assistant secretary; Dr. G. A. Irland, Sunbury Division manager; Professor J. B. Miller, Sunbury Division, technical discussion group chairman; H. H. Angel, past chairman, Meetings and Papers Committee; D. L. Greene, Lehigh Valley Section chairman; J. H. Black, outgoing Section chairman; W. F. Dunkle, Hazleton Division vice-chairman; F. S. Fehr, Section secretary and treasurer; D. E. Albertson, Williamsport Division, Meetings and Papers Committee; D. A. Campbell, Jr., junior past chairman; P. H. Robbins, Reading Division manager; C. J. Mayer, Williamsport Division manager; H. R. Steward, Hazleton Division manager. Seated left to right around the inside are: R. D. Evans, Wilkes-Barre Division vice-chairman; W. T. Joseph, Wilkes-Barre Division manager; C. G. Appelman, Bethlehem Division manager; L. L. Nonemaker, District 2 Executive Committee secretary; B. B. Fern, Meetings and Papers Committee; H. J. West, Allentown Division manager; S. J. Litrides, Publicity Committee chairman

Controlling Instruments (biennial), Annual Instrument Conference and Exhibit (annual).

A comparison of the number of papers presented at special technical conferences and at General meetings shows that 93 papers were presented at the four conferences held during this Institute year, while 26 papers were presented at the committee's technical sessions at General meetings.

Committee Activity in Standards. Revision of standard on recording and controlling instruments of the self-balancing type through American Standards Association (ASA) Committee *C39.2*. A draft incorporating preliminary revisions has been prepared for circulation to groups and manufacturers not represented on the committee. Detailed requirement sheets covering each major class of instruments covered by the standard have been planned.

Development of AIEE Standard Number *4*, for measurement of voltage in dielectric tests, through ASA Committee *C68.1*. This standard was approved by the ASA September 11, 1953, and has been officially issued.

Master test code for power measurements. The subcommittee's final draft has been approved by the committee. The draft has been presented to the Standards Committee. Collaborative study by interested American Society of Mechanical Engineers committees has been set up.

Proposed standard specification forms for electronic instruments. Final drafts from the cognizant subcommittee have been formally submitted to the Electronics Committee and to the Instruments and Measurements Committee. Ballotting is almost complete and final committee redraft incorporating revisions is being readied for presentation to the Standards Committee.

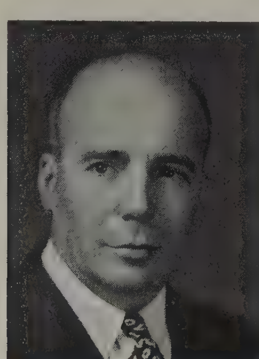
Master test code for rotary speed measurements. The cognizant subcommittee has completed an initial draft which has been informally referred for comment to the Test Code Subcommittee of the Rotating Machinery Committee. A canvass of manufacturers on current practice is in preparation.

Glossary of terminology and definitions for the field of telemetering. The cognizant subcommittee has virtually completed its glossary of terminology and definitions for the field of telemetering, with 192 terms having been processed for suitable form.

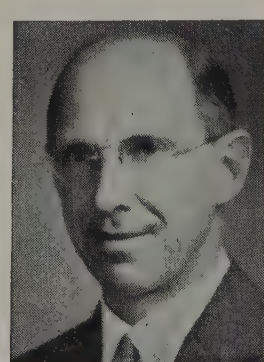
AIEE PERSONALITIES.....

D. D. Ewing (AM '11, F '21, Member for Life), head, School of Electrical Engineering, Purdue University, Lafayette, Ind., retired June 30, 1954. Dr. Ewing was born on October 7, 1883, in Vanlue, Ohio, and was graduated from Ohio Northern University in 1905 in electrical engineering and in mechanical engineering in 1906. He did graduate work at Purdue University, majoring in electric railway engineering during 1912–13. In 1936 he received an honorary degree of doctor of engineering from Ohio Northern University. Dr. Ewing's first engineering work was with the Central District Printing Telegraph and Telephone Company, Pittsburgh, Pa. He soon joined the engineering staff of the Missouri Pacific Railroad as an assistant engineer in the general offices at St. Louis, Mo. In 1907 he returned to Ohio Northern University, Ada, as an instructor in electrical and mechanical engineering. In 1912 he entered Purdue University as a graduate student and a year later he was appointed assistant professor of electrical engineering. In 1916 he was named associate professor and in 1918 professor of electric railway engineering. At Purdue his special fields of work for many years have been in electric power and electric railways. He became head of the School of Electrical Engineering in 1942. He is the author of several articles published by the technical press and served from 1922 to 1932 as a member of the Joint Committee on Welded Railway Joints. Dr. Ewing is a member of the American Society for Engineering Education, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi. A Director of the AIEE (1951–55), he has served on the following Institute committees: Electric Welding (1932–44); Transmission and Distribution (1936–42); Land Transportation (1936–42); Code of Principles of Professional Conduct (1942–50, Chairman, 1945–47); Volta Scholarship Trustees (1951–57); Edison Medal (1951–55); Student Branches (1953–54); Constitution and Bylaws (1953–54, Chairman, 1953–54); Members-for-Life Fund (1953–54); Hoover Medal Board of Award (1953–54); Washington Award Commission (1953–54); and as representative to Engineers' Council for Professional Development (1951-54).

D. D. Ewing



T. M. Linville



Robin Beach

T. M. Linville (AM '27, F '47), manager, research operation services department, General Electric Company, Schenectady, N. Y., has been elected president of the New York State Society of Professional Engineers. Mr. Linville was born March 3, 1904, in Washington, D. C., and was graduated from the University of Virginia in 1926 with the degree of electrical engineer. He joined General Electric that same year on the test course in Schenectady, N. Y., transferring in 1927 to the Motor Engineering Division, Pittsfield, Mass. From 1928 to 1931 he was with the Engineering General Division in Schenectady, taking the advanced course in engineering. He served with the Aeronautic Division from 1932 to 1933 and with the Motor and Generator Engineering Division from 1933 to 1946. He joined the staff of the manager of engineering, apparatus department, in 1947. He became management consultant for the Management Consultation Services Division in New York City in 1951 and was appointed manager, manager development services department, in 1952. During World War II, Mr. Linville served as a member of the U. S. Naval Technical Missions at Pearl Harbor in 1942 and Europe in 1945. He received the Charles A. Coffin Award for outstanding development of design methods for submarine propulsion equipment. He attended the Graduate School of Business Administration, Harvard University, in 1950. Mr. Linville is a member of The American Society of Mechanical Engineers, American Society for Engineering Education, National Society of Professional Engineers, American Association for the Advancement of Science, Society for the Advancement of Management, and the American Management Association. He is a Director of the AIEE and has served on several committees, including Sections, Rotating Machinery, Education, Membership, and Publication.

Robin Beach (AM '15, F '35 Member for Life), head, Robin Beach Engineers Associated, Brooklyn, N. Y., was awarded the honorary degree of doctor of engineering by the University of New Hampshire, June 6, 1954. This honorary degree was conferred on him "in recognition of his outstanding contributions in the field of electrical engineering and of his many and distinguished attainments." He received his bachelors degree in electrical engineering in 1913 and the professional electrical engineer degree in 1922, both from the University of New Hampshire. Also in 1922 he received a master of science degree in physics from New York University. He served as head of the electrical engineering department at the Polytechnic Institute of Brooklyn, N. Y., for 25 years until 1945, and since then he has an honorary status there. During 11 years of this period, he was concurrently director of education for the Brooklyn Edison Company, and later, for the Consolidated Edison Company of New York, Inc. In

1944 he organized his own consulting engineering firm of Robin Beach Engineers Associated. He is the author of three books and numerous technical articles. He is a member of the Institute of Radio Engineers, the American Society for Engineering Education, the American Association of University Professors, the American Association for the Advancement of Science, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. He has served on the President's Conference on Industrial Safety and the President's Conference on Occupational Safety. Dr. Beach has served on the AIEE Committees on the Production and Application of Light, Education, and Safety.

F. S. Black (AM '34, M '44), editor, *Electrical World*, McGraw-Hill Publishing Company, New York, N. Y., has been appointed publisher of the magazine. He will continue as editor. Mr. Black, a native of Bryson City, N. C., graduated from the University of North Carolina in 1933. He joined McGraw-Hill as editor of *Electrical World* after a number of years' experience in public utilities, first with Nantahala Power and Light Company, Bryson City, N. C., and later with Potomac Electric Power Company, Washington, D. C., as assistant system planning engineer and as assistant to the president. Mr. Black is a member of the bar of the District of Columbia and is a registered engineer in the state of Virginia. He has served on the following AIEE committees: Membership (1946–51, Chairman, 1948–50); Sections (1947–52); Professional Division Advisory (1950–52); Constitution and Bylaws (1952–54); Management (1952–53); and the Engineers Joint Council Committee on International Relations (1952–53).

R. K. Connelley (AM '43), electrical engineer, Blaw-Knox Company, Pittsburgh, Pa., has been appointed electrical design engineer with the central engineering staff of Aluminum Company of America, Pittsburgh. Mr. Connelley received his bachelor of science degree in electrical engineering from Carnegie Institute of Technology in 1926 and has held positions with Carnegie-Illinois Steel Corporation, Jones and Laughlin Steel Corporation, Duquesne Light Company, and the Blaw-Knox Company.

W. C. Hutchins (M '42), manager, special products section, General Electric Company, Schenectady, N. Y., has been named manager of product planning for the meter and instrument department, Lynn, Mass. A native of Spartanburg, S. C., Mr. Hutchins was graduated from Clemson College in 1928 and joint General Electric as a student engineer the same year. After completing the test program at the Lynn Works in 1930, he was transferred to the industrial engineering department at Schenectady. Six years later he became a member of the industrial control section and in 1940 joined the special products section where he was appointed manager the following year.

A. J. Ackerman (M '49), consulting engineer,Madison, Wis., has been cited for outstanding engineering accomplishment in his field by the University of Wisconsin College of Engineering. Mr. Ackerman, born in New Ulm, Minn., in 1901, received his bachelor of science degree in electrical engineering from the University of Wisconsin in 1926 and his civil engineer degree in 1932. He has played a leading part in the planning and construction of some of the world's largest hydroelectric developments. He was chief engineer for the Madden Dam in Panama in 1931-33 and head construction planner for the Tennessee Valley Authority in 1933-37. From 1938 to the end of World War II he served as director of engineering for the Dravo Corporation, Pittsburgh, Pa., and served as consultant to the Navy and war Departments in Washington, D. C. Before establishing his consulting practice in Madison in 1952, Mr. Ackerman resided for 6 years in Sao Paulo, Brazil, where he was in charge of hydroelectric construction for the Rio de Janeiro and Sao Paulo Tramway, Light, and Power Companies. Mr. Ackerman is a member of the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the American Institute of Consulting Engineers.

D. W. McLenegan (AM '24, F '53), manager of technical personnel and education, Hanford Atomic Products Operation of the General Electric Company, Richland, Wash., has been cited for outstanding engineering accomplishments in his field by the University of Wisconsin College of Engineering. Mr. McLenegan was born in Milwaukee, Wis., in 1900 and graduated from the University of Wisconsin in 1921 with his bachelor of science degree in mechanical engineering. He joined the General Electric Company in 1922 as a research assistant, later became application engineer with the industrial engineering department, and in 1932 became commercial engineer with the air-conditioning department. Since 1948 Mr. McLenegan has served as manager of technical personnel and education for the Hanford Atomic Products Division. He has served on the AIEE Committee on Education (1951-53).

R. C. Siegel (M '42), chief engineer, Wisconsin Telephone Company, Milwaukee, has been cited for outstanding engineering accomplishment in his field by the University of Wisconsin College of Engineering. Mr. Siegel, born in Los Angeles, Calif., in 1898, received his bachelor of science degree in electrical engineering from the University of Wisconsin in 1921 and immediately began his long association in the engineering department of the Wisconsin Telephone Company, first as transmission and protection engineer. He was promoted to toll fundamental plan engineer in 1923, to plant extension engineer in 1928, assisted the company's chief engineer in the preparation of rate case studies in 1931-35, and has served as chief engineer of the company since 1946.

S. H. Hanville, Jr. (AM '39, M '49), vice-president—engineering, Royal Electric Company, Inc., Pawtucket, R. I., has joined Jack and Heintz, Inc., as manager of technical sales. During World War II, Mr. Hanville served as a lieutenant in the U. S. Navy. For 8 years he headed the power section of the Navy's Bureau of Aeronautics responsible for the development of electric power systems and equipment on all naval aircraft. His naval service was preceded by 3 years as designer of d-c motors and generators with Westinghouse Electric Corporation. He is a graduate of Case Institute of Technology and has done graduate work at Case, Massachusetts Institute of Technology, Harvard, and the University of Pittsburgh. He is a member of the Society of Automotive Engineers, Tau Beta Pi, and Eta Kappa Nu, and is serving on the AIEE Committee on Air Transportation (1947-54).

M. S. Oldacre (AM '13, F '47, Member for Life), former director of research, Commonwealth Edison Company, Chicago, Ill., has joined the senior scientific staff of Stanford (Calif.) Research Institute. Mr. Oldacre will participate in developmental studies of energy in the division of economics and his primary attention will be on problems of the electrical utility industry. A graduate of Purdue University, he has had 28 years of experience in the utility industry. He is a member of the American Standards Association, Tau Beta Pi, International Congress for Large Electric High-Tension Systems (CIGRE), and the American Meteorological Society. He has served on the following AIEE committees: Electrical Machinery (1939-47, Chairman, 1946-47); Standards (1943-48); Transfers (1943-45); Award of Institute Prizes (1946-47); Technical Program (1946-47); and Nucleonics (1950-54).

G. L. Welch (AM '49), district engineering manager, Westinghouse Electric Corporation, Chicago, Ill., has been appointed regional engineering manager of the Mid-America Region of the company. **R. D. Borgstadt** (AM '41, M '48), consulting and application engineer in the Chicago office, has been named district engineering manager. Mr. Welch is a graduate of the University of Minnesota and has been with Westinghouse since 1943. Mr. Borgstadt, a graduate of the University of Iowa, joined Westinghouse in 1940.

A. E. Cooper (AM '50), project engineer, defense development engineering, International Business Machines Corporation, Vestal, N. Y., has been appointed development engineer in the Defense Development Engineering Laboratory. Mr. Cooper, who joined the company in 1950, began as a technical engineer in the physics laboratory and the following year was assigned a similar position in defense engineering. Since October 1952 he has been a project engineer in defense development engineering. A native of Muskegan, Mich., Mr. Cooper attended the University of Cincinnati and earned bachelor and master of science degrees in electrical engineering from Purdue University. He served as a first lieutenant in the Army Air Force during World War II. He is a member of Eta Kappa Nu, Tau Beta Pi, and the Institute of Radio Engineers.

Simon Ramo (AM '40, F '51), vice-president and executive director, the Ramo-Wooldridge Corporation, Los Angeles, Calif., has been elected to the board of directors of Thompson Products, Inc., Cleveland, Ohio.

Dr. Ramo was born in Salt Lake City, Utah May 7, 1913, and received his bachelor of science degree in electrical engineering from the University of Utah in 1933, and his doctorate from California Institute of Technology in 1936. From 1936 to 1946 he was a member of the research staff of the General Electric Company. He joined Hughes Aircraft Company, Culver City, Calif., in 1946 as director of research, electronics department. He later became director of guided missile research and development and then vice-president—operations. In 1953 he organized the Ramo-Wooldridge Corporation. Dr. Ramo is a research associate of the California Institute of Technology and is the author of two textbooks and numerous technical articles. He holds over 25 patents. Dr. Ramo is the recipient of the Eta Kappa Nu Award for the outstanding young electrical engineer and the Electronic Achievement Award of the Institute of Radio Engineers. He is a fellow of the American Physical Society and the Institute of Radio Engineers, and a member of Sigma Xi, Eta Kappa Nu, Phi Kappa Phi, and Tau Beta Pi. He is serving on the AIEE Committee on Electronics (1949-54).

E. E. Charlton (AM '45), head, X-ray section, Research Laboratory, General Electric Company, Schenectady, N. Y., has been appointed consultant to the nucleonics and radiation section of the laboratory. Dr. Charlton is a native of Cherokee, Iowa, and a graduate in 1913, of Grinnell College. He received his doctorate in chemistry from the University of Illinois in 1918. During that year and the next he was a lieutenant in the Chemical Warfare Service of the U. S. Army. Later in 1919, after holding an instructorship in chemistry at the University of Illinois, Urbana, he joined the Jackson Laboratory of E. I. du Pont de Nemours and Company to do research in dye chemistry. He became a member of the staff of the General Electric Research Laboratory in 1920. In 1928 he was placed in charge of the X-ray section. Dr. Charlton has served on the following AIEE committees: Therapeutics (1946-49, Chairman, 1947-48); Communication and Science Co-ordinating (1947-49); Standards (1947-49); and Technical Program (1947-49).

I. S. Lerner (AM '49), electrical engineer, Armour Research Foundation, Chicago, Ill., has been named supervisor of the computer systems section in the electrical engineering department. Mr. Lerner has been with the foundation since 1951. A native of New York City, he received his bachelors degree in electrical engineering in 1948 from Oklahoma Agricultural and Mechanical College. From 1948 to 1951 he was with the geophysics exploration research department of the Continental Oil Company, Ponca City, Okla. Mr. Lerner is a member of the Association for Computing Machinery, Institute of Radio Engineers, and Society for Exploration Physicists.

L. E. Clover (M '51), plant engineer, River Works, General Electric Company, Lynn, Mass., has been named manager of plant engineering and maintenance services in the General Electric Realty Corporation, Schenectady, N. Y. Mr. Clover joined General Electric on its test engineering program following graduation from the University of Nevada in 1928 with a degree in electrical engineering. He was on various assignments in induction motor engineering and in 1936 was transferred to the Oakland, Calif., plant on motor engineering and manufacturing. In 1937, Mr. Clover was placed in charge of cost reduction activities in the induction motor department in Schenectady and in 1940 he joined the company's technical recruiting staff. In 1943 he was transferred to the River Works at Lynn as superintendent of test. In 1948 he was made assistant supervising engineer, and a year later became plant engineer.

W. M. McCauley (AM '26), vice-president and assistant manager, Railway and Industrial Engineering Equipment Division, I-T-E Circuit Breaker Company, Greensburg, Pa., resigned April 1, 1954, because of ill health. Mr. McCauley has been associated with the company for 38 years, starting out in the drafting department. He transferred to sales in 1920, and was manager of the Pittsburgh, Pa., district office for 9 years. He was sales manager for the division from 1929 to 1941 when be became vice-president and assistant manager of the Greensburg factory. He is serving on the AIEE Committee on Substations (1948-54). **H. K. Wilcox, Jr.** (AM '48), sales manager, Railway and Industrial Engineering Equipment Division, has been appointed assistant manager and also will continue as sales manager. Mr. Wilcox came to the division from the I-T-E factory in Philadelphia, Pa., in 1953, where he was assistant sales manager of the Switchgear Division. He joined I-T-E in 1936, and served in various capacities in the sales department until 1949 when he became assistant sales manager of the Switchgear Division.

K. L. Wildes (AM '21, F '40, Member for Life), associate professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, has been appointed a full professor. **D. C. White** (AM '45), assistant professor of electrical engineering, has been promoted to associate professor, and **M. M. Riaz** (AM '51) has been named an instructor in the department of electrical engineering.

F. L. Hermach (AM '44, M '50), electrical engineer, electrical instruments section, National Bureau of Standards, Washington, D. C., has received the Department of Commerce Silver Medal for Meritorious Service for "a very valuable contribution to standardization of electrical measurements in the development of a highly accurate transfer instrument for measurements." Mr. Hermach has been a member of the staff of the Bureau of Standards since 1939. He received his bachelor of science degree from George Washington University in 1943.

S. R. Gilford (AM '42), group leader, electronic instrumentation section, National Bureau of Standards, Washington, D. C., has received the Department of Commerce Silver Medal for Meritorious Service for "very valuable contributions to electronic instrumentation in the field of biophysics." After graduating from Massachusetts Institute of Technology with a degree in electrical engineering in 1941, Mr. Gilford was employed by the Naval Ordnance Laboratory, where he remained until coming to the Bureau of Standards in 1948. He is a member of the Institute of Radio Engineers and is serving on the AIEE Committee on Electrical Techniques in Medicine and Biology.

J. G. Reid, Jr. (AM '46, M '48), general manager, ACF Electronics, Alexandria, Va., has received the Department of Commerce Gold Medal Award for Exceptional Service for "outstanding contributions, as a member of a group, in the field of production technology for electronics with important implications for the electronics industry and for National Defense." Mr. Reid and five other scientists who also received the award were responsible for the development of the "Project Tinkertoy" program. Mr. Reid was born in 1911 in Warren, Ark. He received his bachelors and masters degrees in physics from the University of Mississippi and taught from 1936 to 1937 at the Radio Corporation of America Institutes, Chicago, Ill. He was a staff member of the Museum of Science and Industry, Chicago, from 1933 to 1936 and joined the staff of the National Bureau of Standards in 1937. In 1941 he became a project engineer at the Bureau working on the design and development of electrical and electronic control equipment for uranium isotope separation. In 1943 Mr. Reid joined the program for development of radio proximity fuzes and from 1944 he directed a major project in this field. Following this work Mr. Reid served as chief engineer for the Electronic Instrumentation Laboratory. From 1950 to 1953 he was chief of the Electronics Division. He joined ACF Electronics in 1954. Mr. Reid has served on the following AIEE committees: Electronics (1947-54); Instruments and Measurements (1948-54, Chairman, 1953-54); Electrical Techniques in Medicine and Biology (1951-52); and Science and Electronics Division (1952-54).

M. J. Kelly (M '26, F '31), president, Bell Telephone Laboratories, Inc., New York, N. Y., has been awarded the Industrial Research Institute's 1954 Medal "for distinguished leadership in industrial research, joining the mind of the scientist and the hand of the technologist to serve the security and well-being of mankind, and for outstanding personal contributions to national security."

C. L. Meteer (AM '50), textile specialist, Owens-Corning Fiberglas Corporation, Washington, D. C., has been named to the firm's Sales Builders' Club in recognition of his outstanding 1953 record. A member of the Fiberglas organization since 1948, Mr. Meteer has served the company as head of the Electrical Testing Laboratory and as technical representative in the Electrical Sales Division. He presently is in charge of government sales for the Textile Products Division. A graduate of Ohio State University, Mr. Meteer is a member of the Society of Naval Architects and Marine Engineers, Society of the Plastics Industry, Inc., and the American Ordnance Association.

E. C. Clark (AM '42, M '49), application engineer, General Electric Company, Schenectady, N. Y., has been placed in charge of General Electric's activity in the gas industry. Mr. Clark will co-ordinate activities in the use of gas turbines in various industries with particular emphasis on natural-gas pipe-line pumping. A native of Wesley, Iowa, he was graduated from the University of Iowa with a bachelor of science degree in electrical engineering, joining General Electric on the test course in 1941. He served as an a-c motor and generator designer in the large motor and generator department and was graduated from the company's advanced engineering course. He then became an application engineer in the chemical and petroleum engineering section, serving both in Schenectady and Los Angeles, Calif.

J. G. Dille (AM '49), public relations office, Westinghouse Electric Corporation, New York, N. Y., has been named manager of public relations for the Westinghouse Lamp Division. A native of Fort Morgan, Colo., Mr. Dille attended Colorado School of Mines for 2 years prior to serving in the U. S. Navy as an aviation radar technician during World War II. He was graduated from the University of Colorado with an electrical engineering degree in 1948 and that same year joined Westinghouse on the graduate student course. In March 1949, he joined the technical publicity section of the public relations department in Pittsburgh, Pa. He served in this capacity until August 1953, when he transferred to the New York public relations office.

J. D. Vickrey (AM '45), assistant manager, Lee Electric Manufacturing Company, Los Angeles, Calif., has joined the engineering department of International Rectifier Corporation, El Segundo, Calif., as sales and application engineer. A graduate electrical engineer from the University of Southern California, he also has been associated with Vickers Electric Division, Vickers, Inc., El Segundo.

H. J. Finison (AM '43, M '47), assistant chairman, electrical engineering research department, Armour Research Foundation, Chicago, Ill., has been appointed director of engineering of National Pneumatic Company, Inc., and Holtzer-Cabot Divisions, Boston, Mass. Mr. Finison has served on the AIEE Committee on Air Transportation (1953-54).

D. D. Coffin (AM '25), manager, Missile and Radar Division, Raytheon Manufacturing Company, Waltham, Mass., has been named an assistant vice-president of the firm. Mr. Coffin is a graduate of Harvard, where he took his electrical engineering degree. He began his career in 1924, and during a period of employment with the General Electric Company, he was assigned to special studies in Germany. He later worked for the Radio Corporation of America, then joined Raytheon in 1934, where he has served as design and supervisory engineer for the Transformer Division, chief engineer for the Commercial Division, and other positions of increasing responsibility.

H. E. Rothwell (AM '45), manager, General Electric Supply Corporation, Roanoke, Va., has been appointed field engineer, New York Division, Line Material Company, Union, N. J. Mr. Rothwell attended Virginia Polytechnic Institute.

D. A. Griffith (AM '39, M '49), assistant general manager, Pittsburgh (Pa.) Works, Allis-Chalmers Manufacturing Company, has been named general manager of the Pittsburgh Works. Mr. Griffith has been assistant manager at Pittsburgh for the last year. Prior to that he was assistant manager of Allis-Chalmers' Washington, D. C., district office in charge of federal controls and regulations. He is a member of the Engineers Society of Western Pennsylvania.

F. V. Smith (AM '23, F '48), chief electrical engineer, Sargent and Lundy, Chicago, Ill., has been named general manager and **E. G. Norell** (AM '28, M '46), electrical engineer, has been appointed chief electrical engineer. Mr. Smith has served as chief electrical engineer since 1946 and has been active on the following AIEE committees: Electrical Machinery (1932-33); Transmission and Distribution (1939-41, 1943-54, Chairman, 1953-54); Protective Devices (1942-44); Transfers (1942-43); Switchgear (1946-49); Insulated Conductors (1946-52); Washington Award Commission (1948-52); Standards (1948-50); Liaison Representative on Standards (1951-52); and Power Division (1953-54). Mr. Norell, after graduating from the University of Cincinnati with the degree of bachelor of science in electrical engineering, served with several consulting and industrial engineering firms before joining Sargent and Lundy in 1928 in the electrical engineering department. He was made a partner of the firm in 1951. He is serving on the AIEE Committees on Protective Devices (1947-54) and Power Generation (1953-54).

S. H. Simpson, Jr. (M '47), assistant vice-president and district manager, RCA Communications, Inc., Radio Corporation of America, Washington, D. C., has joined Southwest Research Institute, San Antonio, Tex., as supervisor of the communications section of the physics department. Mr. Simpson obtained his degree in electrical engineering from Texas Agricultural and Mechanical College.

F. E. Harrell (AM '26, F '40), vice-president Reliance Electric and Engineering Company, Cleveland, Ohio, has been given the additional duties of director of special projects, a newly created position in which he will be concerned with new building projects and associated growth problems of the company.

Rudolf Feldt (M '46), manager, Instrument Division, Allen B. Du Mont Laboratories, Inc., Clifton, N. J., has joined the Federal Telecommunication Laboratories, New York, N. Y., as manager of the Instrument Division. Mr. Feldt is a graduate of the Institute of Technology, Berlin, Germany, where he received the degree of electrical engineer. Before coming to the United States he was engaged in research and sales engineering in Germany and France. Mr. Feldt became associated with Du Mont in 1942 as research engineer and had been manager of the Du Mont Instrument Division since 1947. He is serving on the AIEE Committees on Electronics (1947–54) and Instruments and Measurements (1950–54).

C. E. Boulson (AM '40, M '47), acting manager, Sho-Me Power Corporation, Marshfield, Mo., has been appointed general manager. Mr. Boulson is a graduate of the Missouri School of Mines and Metallurgy with a bachelor of science degree in electrical engineering. He was associated with the Missouri Electric Power Company and later became chief engineer of Sho-Me in 1944, a position he held until becoming acting manager in December 1953. Mr. Boulson is a member of Tau Beta Pi, National Society of Professional Engineers, and Missouri Society of Professional Engineers.

D. B. Kendall (AM '52), senior electrical engineer, Toledo (Ohio) Scale Company, has been named assistant to the director of engineering. Mr. Kendall joined the engineering division of Toledo Scale in 1937 and is chairman of the motor and controls committee of the Toledo Section of the AIEE.

W. H. England (AM '41), field engineer, Line Material Company, Southwick, Mass., has been transferred to the protective equipment sales department, Milwaukee, Wis., as a sales application engineer. **C. L. Hopkins** (AM '54) will replace Mr. England and will handle sales in Connecticut and Western Massachusetts. Mr. Hopkins will have his office in Agawam, Mass. Mr. England received his bachelor of science degree in electrical engineering from Northeastern University in 1940. He joined Line Material in 1949 after 6 years' service in the U. S. Air Force and 3 years' employment in sales engineering. After graduating from Tufts College in 1944, Mr. Hopkins did sales engineering work. He is a member of the Engineers' Society of Western Massachusetts.

F. D. Knight (M '25, F '50), vice-president, Connecticut Power Company and Hartford (Conn.) Electric Light Company, retired recently. Mr. Knight is a native of Limerick, Maine, and was graduated from the University of Maine with a bachelor of science degree in electrical engineering. He joined the Hartford Electric Light Company in 1941 as assistant to the vice-president, after service with the Boston (Mass.) Edison Company as assistant superintendent and superintendent of production. In 1947 Mr. Knight became vice-president in charge of operations, engineering, and construction for the Hartford Electric Light Company, and of engineering and power plant operation for the Connecticut Power Company. He was formerly construction superintendent for the Stone and Webster Engineering Corporation in charge of power plant construction in numerous states. In that capacity he was

superintendent on the original development of the South Meadow steam generating station at Hartford in 1920. A short time later he supervised the construction of the world's first mercury vapor generating unit at Dutch Point. When he later joined the Hartford company in 1941, he supervised the major generating plant construction programs of the company. He has been active on national engineering committees of the Edison Electric Institute and the Association of Edison Illuminating Companies. He is a member of The American Society of Mechanical Engineers and received the degree of doctor of engineering in 1950 from the University of Maine. He has served on the AIEE Committee on Safety (1930–39, Chairman, 1934–35).

S. V. Dillon (AM '45), manager, electrical products, Johns-Manville Corporation, New York, N. Y., has been named manager for electrical equipment industry of the special industries department. Mr. Dillon joined Johns-Manville in 1920 as secretary to the general manager, electrical and auto equipment departments. In 1937 he was named assistant staff manager for electrical products and in 1949 was appointed manager for electrical products. Mr. Dillon studied electrical engineering at Pratt Institute and is a member of the International Municipal Signal Association and the International Association of Electrical Inspectors.

Ralph Bown (M '30, F '41), vice-president in charge of research, Bell Telephone Laboratories, Inc., Murray Hill, N. J., has been placed in charge of the long-range planning of Laboratories programs. He will continue as vice-president and also will continue his responsibilities in connection with the patent department. Before his appointment as vice-president in charge of research in 1952, Dr. Bown had served as director of research since 1946. He served as a captain in the Signal Corps in World War I, prior to joining the research and development department of the American Telephone and Telegraph Company. He was named assistant director of radio research of the Laboratories in 1934, director of radio and television research in 1936, and assistant director of research in 1944. Dr. Bown was awarded the Morris Liebman Memorial Prize by the Institute of Radio Engineers for 1926 and in 1949 he received that institute's annual Medal of Honor. He is a fellow and past president of the Institute of Radio Engineers, and a fellow of the American Association for the Advancement of Science, the Acoustical Society of America, and the American Physical Society. He received his bachelors, masters, and doctors degrees from Cornell University.

E. C. White (AM '44), industrial specialist, tube department, General Electric Company, Schenectady, N. Y., has been named product manager for General Electric industrial and transmitting tubes. A native of Pittsburgh, Pa., Mr. White was graduated from Carnegie Institute of Technology in 1943 and joined General Electric shortly after on the company's test engineering program at Erie, Pa. He joined the tube department in 1944. He held successive assignments as the department's engineering representative at the Oak Ridge, Tenn., atomic energy plant, as district representative for industrial and transmitting tube sales in the Washington-Baltimore-Philadelphia area, and as supervisor for the sales of mercury switches. In 1951 he was named assistant to the sales manager for industrial and transmitting tubes and in early 1953 he was named industrial specialist. Mr. White is a member of Eta Kappa Nu.

D. H. Apgar (AM '50), designer, International Business Machines Corporation, Endicott, N. Y., has been appointed technical engineer in production engineering. Mr. Apgar joined International Business Machines in 1949 as a student in the engineering training program, and upon completion of his training was assigned to research engineering. In April 1951 he was transferred to production engineering as a designer. Mr. Apgar graduated from Lafayette College with a bachelor of science degree in electrical engineering in 1949. During World War II he served with the U. S. Army Security Agency.

H. H. Varhus (AM '37, M '47), chief of product engineering division, technical services department, Naval Ordnance Laboratory, White Oak, Md., has been named deputy chief of the department. Mr. Varhus joined the Laboratory in 1941 after having been employed previously with Northern States Power Company, Minneapolis, Minn., where he served as inductive coordination engineer in the transmission and distribution department. Mr. Varhus obtained his bachelor of electrical engineering degree in 1936 at the University of Minnesota.

A. W. Bradt (M '26, F '45), secretary and general manager, Hamilton Hydro-Electric System, Hamilton, Ont., Canada, retired recently. He has been retained as a consultant to the commission for 5 years. Mr. Bradt started his career with Dominion Power and Transmission Company in 1909, transferring to Hamilton Hydro-Electric in 1912, a year after the system was formed.

M. D. Bergan (M '49), research director, Thomas and Betts Company, Elizabeth, N. J., has been appointed engineering technical director. **L. M. Curtiss** (AM '48), executive engineer, has been named assistant chief engineer in charge of development.

E. T. Carlson (AM '35, M '48), retired, Plainville, Conn., has been named vice-president and general manager of Roller-Smith Corporation, Bethlehem, Pa. A native of New England, Mr. Carlson is a graduate of Northeastern University, Boston, Mass., where after graduation he was a member of the faculty. He later became identified with the Trumbull Manufacturing Company as sales representative in the New England territory. He became sales manager, plant manager, and finally president of Trumbull, which later became affiliated with General Electric and finally was brought into the corporate structure. While with Trumbull and General Electric, Mr. Carlson built and managed plants in Maspeth, N. Y.; Cincinnati, Ohio; Houston, Tex.; North Hollywood and San Francisco, Calif.; Seattle, Wash.; and Ludlow, Ky., which later was moved to Norwood, Ohio. Mr. Carlson is a member of the National Electrical Manufacturers Association, and Tau Beta Pi. He has served on the AIEE Committee on Industrial Power Applications (1940–46).

I. L. Auerbach (AM '48), power engineer, electronics department, Burroughs Corporation, Philadelphia, Pa., has been named director of the Special Products Division at the Burroughs Research Center. A native of Philadelphia, Mr. Auerbach received his bachelor of science degree in electrical engineering in 1943 from Drexel Institute of Technology. He has done graduate work at both Massachusetts Institute of Technology and Harvard University, from which he received his masters degree in applied physics in 1947. From 1943 to 1946 Mr. Auerbach was a navy radar officer; in 1945 he was assigned to the Naval Research Laboratory for work in IFF systems. Prior to joining Burroughs Research in 1949, he worked on the BINAC and UNIVAC systems at the Eckert-Mauchly Division, Remington Rand Inc., Philadelphia. At Burroughs Research, Mr. Auerbach has been engaged in the design of electronic data-processing systems and has initiated work on magnetic components and circuits; he was responsible for the design of the static magnetic memory system for the ENIAC. He has written numerous technical articles and holds patents in the field of electronic circuits and systems. He is a member of the Institute of Radio Engineers, Association for Computing Machinery, the Scientific Research Society of America, and Eta Kappa Nu, and is a registered professional engineer in Pennsylvania.

G. W. Knapp (AM '45, M '53), manager of paper and textile engineering, industrial engineering section, General Electric Company, Schenectady, N. Y., has been named manager of engineering practices. **C. J. Meloun** (AM '53), acting manager, equipment subsection, industry control engineering, has been named manager of paper and textile engineering, and **J. J. W. Brown** (M '51), application engineer in materials handling and testing equipment subsection, has been named manager of materials handling and testing equipment engineering. Mr. Knapp has been serving as manager of paper and textile engineering since 1947. He joined General Electric on the test course in 1936 after being graduated from Rensselaer Polytechnic Institute, and worked as a design engineer on industrial control. He later transferred to industrial control sales for commercial training. In 1939 he became associated with the industrial engineering department as a paper mill application engineer. During the war he was assigned to the rubber industry section, becoming manager of rubber and printing section in 1945. Two years later he returned to the

paper and textile section as manager. Mr. Knapp is a member of the Technical Association of the Pulp and Paper Industry and is serving on the AIEE Committee on General Industry Applications (1947–52, 1953–54). Mr. Meloun began his career with General Electric in 1942, following his graduation from Case Institute of Technology. Starting on the test course, he served at the company's Erie (Pa.) Works, Lynn (Mass.) River Works, and Schenectady (N. Y.) Works. This was followed by an assignment in service engineering where he did field service work on aircraft fire control equipment. In 1945 he was transferred to the control department as a requisition engineer on steel mill control. From 1947 through 1951 he served as an application engineer in the paper and textile engineering subsection. He then was assigned to industry control engineering, where in November 1952 he was made acting manager of the equipment subsection. Mr. Meloun is a member of the Technical Association of the Pulp and Paper Industry. Mr. Brown is a graduate of Purdue University with a degree in electrical engineering. He started on the General Electric test course in 1940, after which he was assigned to aeronautics and marine engineering. From 1941 to 1947 he served as a development engineer on naval ordnance. Since then he has been an application engineer. He is a member of Tau Beta Pi and Sigma Xi and is serving on the AIEE Committee on General Industry Applications (1953–54).

Edith Clarke (AM '23, F '48), professor of electrical engineering, University of Texas, Austin, has been chosen by the Society of Women Engineers as the 1954 recipient of their annual award to a woman who has made significant contribution to engineering. Miss Clarke is a graduate of Vassar College and received a master of science degree in electrical engineering from Massachusetts Institute of Technology. For many years she was a member of the central station engineering department of the General Electric Company, Schenectady, N. Y. Earlier she was a teacher of mathematics and science in San Francisco, Calif., and Huntington, W. Va., then a computer at the American Telephone and Telegraph Company, New York, N. Y. She also spent a year as professor of physics at the Constantinople Women's College in Turkey. Since her retirement from the General Electric Company in 1945, Miss Clarke has been professor of electrical engineering at the University of Texas. She is a member of the American Society for Engineering Education, Phi Beta Kappa, Sigma Xi, and Tau Beta Pi, and the Society of Women Engineers. She has served on the AIEE Committees on Power Transmission and Distribution (1925–27) and Code of Principles of Professional Conduct (1950–53).

H. A. Winne (AM '16, F '45, Member for Life), retired, General Electric Company, Schenectady, N. Y., has been chosen as the recipient of the National Society of Professional Engineers' Award. Mr. Winne "was selected both because of his extraordinary achievements in the fields of invention, design, development, and production and because of his unstinting devotion to professional principles and ideals." Mr. Winne retired recently as vice-president of General Electric. He also recently has been elected a director of the American Gas and Electric Company, New York, N. Y. A graduate of Syracuse University, he joined General Electric as a student engineer on the test course in 1910 and advanced through various technical and administrative posts to the vice-presidency in 1941. He has served with various governmental advisory groups. He received the 1953 James H. McGraw Award and has received honorary doctorate degrees from Syracuse University, Rensselaer Polytechnic Institute, Rhode Island University, and Newark College of Engineering. He is a fellow of The American Society of Mechanical Engineers and a member of the National Society of Professional Engineers, New York State Society of Professional Engineers, and the American Society for Engineering Education. He has served on the following AIEE committees: Applications to Iron and Steel Production (1930–38); Electric Welding (1934–40); and Edison Medal (1947–52).

L. P. Morris (AM '30), chief systems engineer, Motorola, Inc., Chicago, Ill., has been appointed chief engineer, national radio systems consulting service, a new Motorola department. Mr. Morris joined Motorola in 1940 and has served as chief systems engineer since 1947. He is an electrical engineering graduate and former staff member of the University of Illinois. He is a member of the Institute of Radio Engineers, Acoustical Society of America, Society of Motion Picture and Television Engineers, and the Illinois Professional Communication Engineers Association. He has served on the AIEE Committee on Radio Communication Systems (1950–53).

L. J. Kamm (M '46), consulting engineer, New York, N. Y., has joined Schatzki Engineering Company, Springfield Gardens, N. Y., as chief electrical engineer. Mr. Kamm received a bachelor of science degree in electrical engineering from Columbia University in 1941, a masters degree from Brooklyn Polytechnic Institute in 1946. From 1941 to 1946 he was employed by Signal Engineering and Manufacturing Company, and from 1946 to 1950 by the Teleregister Corporation. Since 1950 he has been a consulting engineer and will continue his consulting practice as part of Schatzki Engineering Company work.

E. R. Lawler (AM '20), manager, Toronto Region, Hydro-Electric Power Commission of Ontario, Toronto, Ont., Canada, has been appointed consultant, Toronto Region. Mr. Lawler's service with electrical utilities dates from 1905 when he was employed as a meter reader with the Toronto Electric Light Company. Two years later he enrolled in the University of Toronto and graduated in electrical engineering in 1910. After 4 years with Toronto Hydro-Electric System, he joined Ontario Hydro-Electric and assisted in the promotional work being carried out at the time by Sir Adam Beck. Subsequently he served for more than 25 years as district engineer in southwestern Ontario, becoming district engineer for Toronto and the surrounding municipalities and rural areas in 1943. He was appointed manager of the Toronto Region when it was established in 1947. He is a member of the Association of Professional Engineers of Ontario and the Electric Club of Toronto.

G. M. McHenry (AM '44), Consumer Service Division, Hydro-Electric Power Commission of Ontario, Toronto, Ont., Canada, has been named consumer service engineer, Western Region, London, Ont. Mr. McHenry was born in Toronto and graduated from the University of Toronto with an electrical engineering degree in 1940. He joined the Ontario Hydro-Electric system planning department in 1948. Two years later he became area planning engineer for the Frequency Standardization Division and later was transferred to the Consumer Service Division. He is councillor of the Association of Professional Engineers of Ontario.

P. C. Goldmark (M '45, F '54), vice-president, CBS Laboratories, Columbia Broadcasting System, Inc., New York, N. Y., has been appointed president of CBS Laboratories. Dr. Goldmark joined CBS in 1936 and shortly afterward was named chief television engineer. Since 1950 he has been vice-president of CBS Laboratories. Dr. Goldmark is a fellow of the Institute of Radio Engineers, the Society of Motion Picture and Television Engineers, and the British Television Society. In 1945 he was awarded a medal by the Television Broadcasters Association for his color television work. In 1946, the Institute of Radio Engineers awarded him the Morris Liebman Memorial Prize for electronic research.

F. X. Lamb (AM '36, M '44), chief engineer, and **R. W. Gilbert** (AM '36), research director, Weston Electrical Instrument Corporation, Newark, N. J., have been appointed vice-president and assistant to the president, respectively. Mr. Lamb will retain his former title of chief engineer and will take on additional responsibilities in supervising mechanical and electrical engineering activities. A licensed professional engineer in New Jersey, Mr. Lamb joined the company in 1921. He has served as a design, project, and liaison engineer. In addition to holding many supervisory positions, he was a resident engineer for Weston assigned to the Nippon Electric Company, Tokyo, Japan, from 1937 to 1939. Mr. Lamb is a graduate of the Newark College of Engineering and holds 17 United States and 10 foreign patents. He is a member of the Institute of Radio Engineers, Instrument Society of America, the Radio Club of America, and Eta Kappa Nu. He has served on the AIEE Committee on Instruments and Measurements (1951–52). Mr. Gilbert, in addition to his new post, will continue to serve as director of research. He joined Weston in 1934 as a research engineer and has served as both division chief and laboratory director. He holds 24 patents. A graduate of Lehigh University, Mr. Gilbert is a member of the Institute of Radio Engineers and the Institute of the Aeronautical Sciences. He is serving on the AIEE Committee on Electrical Techniques in Medicine and Biology (1953–54).

W. H. Mackin (AM '52), sales engineer, Holtzer-Cabot Telephone Equipment Division, National Pneumatic Company, Inc., Boston, Mass., has been appointed sales manager of the division.

G. D. Craig, Jr. (M '49), district sales manager, Jack and Heintz Precision Industries, Inc., New York, N. Y., has joined Northwestern Electric Company, Chicago, Ill., as general sales manager.

OBITUARIES • • • •

Segismundo Gerszonowicz (M '44, F '50), professor and head of the department of electrical engineering, Instituto de Electrotecnica Montevideo, Uruguay, died July 10, 1953. Dr. Gerszonowicz was born on October 10, 1909, in Tomaszov Mazowiecki, Poland, and was graduated from the Polytechnical Institute, Grenoble, France, in 1930. After working for a construction company for several months, he became an instructor and research assistant at the Polytechnical Institute, Grenoble. In 1936 he was appointed professor of electrical engineering and head of the electrical engineering department, Instituto de Electrotecnica, Montevideo. From 1946 to 1948 he studied engineering education in other parts of South America, Europe, and the United States. In 1949 he was a visiting lecturer in electrical engineering at Harvard University, Cambridge, Mass. Dr. Gerszonowicz received his degree of doctor of physical science from the University of Grenoble in 1948. He was the author of six books and numerous technical articles, including works on galvanometers and circuit breakers. He was a member of the Asociacion de Ingenieros del Uruguay and the Asociacion Uruguaya para el Progreso de la Ciencia.

Alfred Stevens Glasgow (AM '08, Member for Life), retired, San Diego, Calif., died in January 1954. Mr. Glasgow was born in Bellwood, Pa., December 10, 1878, and was graduated from Pennsylvania State College in 1901. From 1901 to 1916 he was associated with the General Electric Company, first in Schenectady, N. Y., then in San Francisco and Los Angeles, Calif. He joined the San Diego (Calif.) Gas and Electric Company in 1916 as manager of the Oceanside district and later became assistant superintendent of transmission and distribution and then superintendent of transmission and distribution. He retired in 1947.

Francis M. Parsons (M '50), vice-president and sales manager, Kellogg Switchboard and Supply Company, a division of International Telephone and Telegraph Corporation, Chicago, Ill., died May 24, 1954. Mr. Parsons was born in Omro, Wis., March 4, 1898, and began his career with the Northwestern Telephone Company, Bismarck, N. Dak., in 1912. He worked for the Cooperstown, Mandan, and Bismarck exchanges of the company, interrupting his work to serve in World War I. He was a wire chief of the Bismarck exchange from 1921 to 1923. In 1923, Mr. Parsons joined the Kellogg Company's Sales Division, leaving in 1928 to take over the position of superintendent, Telephone Division of the Central Western Public Service Company, Omaha, Nebr. Rejoining the Kellogg Company in 1934, he served successively as manager of its switchboard sales department, supervisor of field representatives, and eastern division manager. In 1944 he was appointed sales manager, and in August 1952, he was elected vice-president. He was vice-president of the Independent Telephone Pioneers Association and served in several committees of the U. S. Independent Telephone Association.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of May 20, 1954, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Abrahams, A. A., vice-pres., Federal Oil Burner Co., Inc., Philadelphia, Pa.
Adams, R. T., application engr., Ambos-Jones Co., Cleveland, Ohio
Albright, J. W., design engg. supv., General Electric Co., Pittsfield, Mass.
Anderson, J. G., developmental engr., General Electric Co., Pittsfield, Mass.
Armstrong, W. H., supt. elec. constr. dept., Consolidated Gas Elec. Lt. & Pr. Co., Baltimore, Md.
Ault, D. L., plant engr., United Telephone Co., Monroe, Wis.
Bailey, J. B., elec. mechanical foreman, Cleveland Electric Illuminating Co., Cleveland, Ohio
Barsun, H. F., section mgr., Westinghouse Electric Corp., Sharon, Pa.
Belsher, M. W., general engr., Bonneville Power Administration, Portland, Oreg.
Berlin, B. A., pres., Heinemann Electric Co., Trenton, N. J.
Berthold, P. W., owner, Berthold Electric & Engg. Co., Akron, Ohio
Bordewieck, R. W., application engr., Signal Instruments, Inc., South Braintree, Mass.
Brainard, W. E., pres., Arcrods Corp., Sparrows Point, Md.
Brown, H. E., design engr., Ontario Paper Co., Ltd., Thorold, Ont., Canada
Brown, W. B., elec. engr., General Electric Co., Pittsfield, Mass.
Buggy, R. V., chief civ. asst. to electronics officer, Philadelphia Naval Shipyard, Philadelphia, Pa.
Cameron, A. W. W., supervising engr., Hydro Electric Pr. Comm. of Ontario, Toronto, Ont., Canada
Carlson, W. A., application engr., Westinghouse Electric Corp., Boston, Mass.
Chamberlain, J. E., electrical engr., Long Island Lighting Co., Mineola, N. Y.
Cook, W. P., division engr., Duquesne Light Co., Pittsburgh, Pa.
Davis, G. H., division engr., The Connecticut Light & Power Co., Waterbury, Conn.
Eadie, T. W., pres., The Bell Telephone Co. of Canada, Montreal, Que., Canada
Ellerman, H. E., Jr., engg. section mgr., Westinghouse Electric Corp., Sharon, Pa.
Evans, E. A., development engr., General Electric Co., Pittsfield, Mass.
Eyman, D. H., mgr., order service dept., Westinghouse Electric Corp., Sharon, Pa.
Frick, B., consulting & application engr., Westinghouse Electric Corp., St. Louis, Mo.
Gibbs, J. C., vice-pres., Citizens Utilities Co., Greenwich, Conn.
Gilbert, M. G., electrical engr., Bonneville Power Administration, Portland, Oreg.
Grabowski, S. J., design engr., General Electric Co., Schenectady, N. Y.
Grim, C. L., engr., electric distribution dept., Consolidated Gas Elec. Lt. & Pr. Co., Baltimore, Md.
Haddy, H. P., supv., relay dept., Philadelphia Elec. Co., Norristown, Pa.
Haynes, R. F., relay engr., General Electric Co., Richland, Wash.
Herold, J. A., asst. engr., Consolidated Gas Elec. Lt. & Pr. Co. of Baltimore, Md.
Herring, R. L., div. plant supv., Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Higginbotham, D. E., assoc. prof. of elec. engg., Hooper Laboratories, Tufts College, Mass.
Hoyt, A. G., mgr., apparatus service shop, General Electric Co., Baltimore, Md.
Hutchinson, R. W., eastern div. mgr., Pacific Electric Mfg. Corp., Chicago, Ill.
Jackson, D. W., elec. engr., Jackson & Moreland, Boston, Mass.
Jager, C. R., senior engr., Alabama Pr. Co., Birmingham, Ala.
Johrde, Paul S., section engr., The Elliott Co., Ridgway, Pa.
Jolly, R. M., asst. supt. of T & D, City Public Service Bd., San Antonio, Tex.
Joseph, H. M., electronic scientist, National Bureau of Standards, Washington, D. C.
Karr, L. A., asst. engr., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Lehr, S. N., engr., General Electric Co., Pittsfield, Mass.
Lobban, R. A., regional mgr., Picker X-Ray Corp., White Plains, N. Y.
Magee, W. P., junior engr., Philadelphia Electric Co., Philadelphia, Pa.
Mangum, O. K., supt., transmission div., U. S. Bureau of Reclamation, Phoenix, Ariz.
Maul, D. T., elec. engr., Union Electric Co. of Missouri, St. Louis, Mo.
McLane, F. E., design engr., Westinghouse Electric Corp., Buffalo, N. Y.
Minneci, S., supv., transformer accessories engg., General Electric Co., Pittsfield, Mass.
Mobarry, K. C., application engr., General Electric Co., Cleveland, Ohio
Nelson, R. A., engr., General Electric Co., Rome, Ga.
Nolte, R. J., senior engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Osthagen, S. O. M., field engr., Allis-Chalmers Mfg. Co., Boston Mass.
Pindar, R. S., Jr., field engr., General Electric Co., Pittsfield, Mass.
Priestley, K., vice-pres., Eastern Electric Construction Co., Bridgeport, Conn.
Reese, E. B., plant elec. engr., Consolidated Western Steel Div., U. S. Steel Corp., Orange, Tex.
Renoff, G. F., asst. engr., Consolidated Gas Elec. Lt. & Pr. Co. of Baltimore, Md.
Riese, R. L., asst. prof. of elec. engg., New Mexico College of A. & M. A., State College, N. Mex.
Roediger, F. E., chief, engg. test sec., Fire Control Branch, Aberdeen Proving Ground, Md.
Salmonson, W. G., asst. chief engr., Pennsylvania Railroad, Philadelphia, Pa.
Schindel, L. M., outside plant design engr., American Tel. & Tel. Co., Kansas City, Mo
Schoonmaker, L. E., assoc. prof. of elec. engg., University of Florida, Gainesville, Fla.
Schnure, R. B., sales engr., General Electric Co., Pittsburgh, Pa.
Seidell, T. G., prof. of elec. engg. emeritus, Georgia Institute of Technology, Atlanta, Ga.
Sias, F. R., engr., General Electric Co., West Lynn, Mass.
Siocos, C. A., engr., Canadian Broadcasting Corp., Montreal, Que., Can.ada
Smith, R. E., director of engg., The A. C. Gilbert Co., New Haven, Conn.
Starbuck, L. W. G., chief engr. & local director, Messrs. Walker Sons & Co., Ltd., Colombo, Ceylon
Stein, R., asst. prof., City College of New York, N. Y.
Stenis, T. B., asst. prof. of elec. engg., Texas Technological College, Lubbock, Tex.
Stephens, D. S., supervising engr., Westinghouse Electric Corp., Sharon, Pa.
Truxal, J. G., assoc. prof. of elec. engg., Purdue University, Lafayette, Ind.
Vaughan, K. A., mgr., field engg., Gould National Batteries, Inc., Trenton, N. J.
Ward, J. W. W., elec. engr., Avondale Mills of Alabama, Sylacauga, Ala.
Warner, C. W., vice-pres., Georgia Pr. & Lt. Co., Valdosia, Ga.
Weitzel, W. G., supt. of meters & auto controls, Narragansett Elec. Co., Providence, R. I.
Wildi, P., chief engr., Pacific Oerlikon Co., Tacoma, Wash.
Wilson, G. P., elec. engr., Jackson & Moreland, Boston, Mass.
Winitsky, H. B., engr., Philadelphia Electric Co., Philadelphia, Pa.
Witkowski, T. T., senior research engr., Consolidated Vultee Aircraft Corp., San Diego, Calif.

81 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before July 25, 1954, or September 25, 1954, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Blakeslee, D. W. (re-election), Bureau of Design, County of Allegheny, Pittsburgh, Pa.
Combes, R. M., Bendix Aviation Corp., Burbank, Calif.
Higgins, H., City Electricity Dept., City Hall, Singapore, British Malaya
Larson, G. C., Westinghouse Electric Corp., Metuchen, N. J.
Sayers, D. P., Midlands Electricity Board, Halesowen, England
Wells, N. S., The Steel Co. of Canada, Ltd., Hamilton, Ont., Canada

6 to grade of Member

Research and Testing Pave Way to Build First American 230-Kv Pipe-Type Cable

When the need for extra-high-voltage cables for handling large amounts of power became apparent, a research program was undertaken at the Okonite Company to develop and build an experimental 230-kv cable. Two 500-foot pilot lengths were made, each having a different type of insulation, and a series of exhaustive tests proved the manufacturing procedure excellent. Because of these tests and other successful cables the Okonite engineers had designed, the company was awarded the contract for a 230-kv Oilostatic cable by the Canadian-Brazilian Services, Ltd., of Toronto, Ont., Canada, for installation in the Cubatao Underground Power Plant of the Sao Paulo Light and Power Company, Ltd., Sao Paulo, Brazil.

The two 500-foot test cables consisted of 750,000-circular-mil concentrically stranded aluminum conductor, 0.835-inch wall of paper insulation including metallized paper tapes over the conductor and over the insulation, copper shielding tapes over the insulation followed by one *D*-shaped copper armor wire, and 0.078-inch temporary lead sheath over all. One length was insulated with 0.005-inch paper throughout while on the second 500-foot length the wall of insulation was graded with papers of 0.003 inch, 0.005 inch, and 0.0065 inch thickness, with the thinner papers placed near the conductor for optimum impulse strengths. Aluminum was used because of the scarcity of copper at the time.

Nature of Preliminary Tests. Both of these 500-foot pilot lengths were subjected to exhaustive electrical tests, as follows:

1. One hundred feet of each cable were sent to British Insulated Callender's Cables, Ltd., for impulse tests. Both cables proved to be excellent on these tests. The sample with insulation of graded paper thicknesses showed a maximum impulse strength of 3,300 volts per mil at the conductor and the sample with paper of uniform thickness a maximum impulse strength of 2,960 volts per mil at the conductor.

2. One hundred feet of each cable were sent to the Ohio Brass Company to be used for checking the impulse strength level of the new potheads built and designed by them for 230-kv service. The potheads were designed for an impulse level of 900 kv, and the test results are best summed up by quoting the Ohio Brass report, which states as follows: "Out of the total of almost 400 shots of impulse voltage applied to the potheads, approximately half were at voltages above the pothead design level of 900 kv and went as high as the next basic impulse level of 1,050 kv. We now feel we have an excellent basic pothead design for this service." See Fig. 1. Each of the two cable designs received approximately 200 shots of impulse voltage. Neither cable nor the splice failed electrically during this testing.

3. Both cables were given a dielectric loss test and high-voltage time test at the Okonite Laboratories. The test setup consisted of a section of cable containing paper of graded thickness and a section of the cable containing all 0.005-inch-thickness papers each with a 230-kv normal joint between the two sections.

The potheads used for terminating the cable at each end of the steel pipe were prototypes of the design proposed for the 230-kv commercial potheads. The primary purpose of this test was to check the design of the prototype potheads.

Results obtained were as follows:

1. Dielectric loss tests on the cable and joint made at an elevated temperature (100 C) indicated a high degree of stability, power factor showing a minimum of 0.39 and a maximum of 0.52 from 30 volts per mil of insulation to 240 volts per mil.

2. On high-voltage time tests, the cable was tested for 6 hours at 284 kv, for 6 hours at 315 kv, and for 3 hours at 358 kv. At 358 kv, the cable and joint showed excellent stability, power factor measuring 0.39 minimum to 0.47 maximum from 120 volts per mil of insulation to 240 volts per mil.

Cable could not be tested at higher voltages because of limitations in high-voltage testing equipment when this test was made. At the present time, equipment can be tested to 700 kv, and a dielectric loss test and high-voltage time test will be made on a piece of the commercial cable with the new higher voltage equipment.

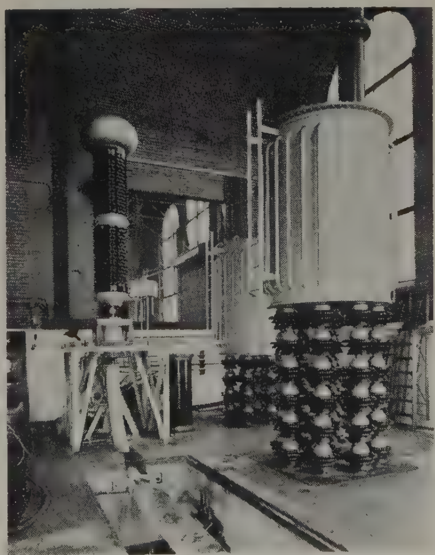


Fig. 1. A 700-kv a-c test pothead and the associated transformer bank used for breakdown test. To complete the cascading of the transformers high-voltage leads are brought in from the ground unit in the adjacent test area through the large opening in the wall. On floor next to stand is a 400-kv test pothead

3. The prototype design of the 230-kv commercial potheads was proved satisfactory as a result of these tests.

In addition, complete physical tests and radial power factor tests were made by the Okonite research laboratory. The results of these tests disclose that the manufacturing procedure carried out on both pilot lengths left little room for improvement.

These Oilostatic circuits for these units will each be approximately 1,500 feet in length. The high-pressure oil cables will be installed without splices. The cables will be fed into a spreader head on a vertical 90° bend in the 8-inch IPS ($8^5/_8$-inch outside diameter) steel pipe which leads into the tunnel, and after negotiating the intermediate bends, it will be pulled through another spreader head on a vertical 90° bend in the power plant. Sufficient cable will be allowed above the spreader head on both ends of the cable circuit to permit the threading of prebend copper pipes, which are used to provide the necessary phase spacing for the three single-conductor cables. Additional cable will be allowed for the assembly of the potheads.

The system was designed by Okonite engineers in co-operation with the engineers of the Canadian-Brazilian Services. The design of the terminals was developed with the assistance of the Ohio Brass Company's technical staff, who had worked on this fea-

Future Meetings of Other Societies

American Society of Refrigeration Engineers. 41st Semiannual Meeting. July 11–14, 1954, Olympic Hotel, Seattle, Wash.

British Institute of Radio Engineers. Convention on Industrial Electronics. July 8–12, 1954, Christ Church, University of Oxford, Oxfordshire, England

Institute of the Aeronautical Sciences. Turbine-Powered Air Transportation Meeting. August 9–11, 1954, Seattle, Wash.

Interamerican Association of Sanitary Engineers. July 25–31, 1954, Sao Paulo, Brazil

International Union of Pure and Applied Physics. 8th General Assembly. July 6–9, 1954, London, England

International Union of Pure and Applied Physics and the Institute of Physics (Great Britain). Conference on Defects in Crystalline Solids. July 13–17, 1954, Bristol, England

Pan-American Federation of Engineering Societies (UPADI). 3d Convention. August 2–12, 1954, Sao Paulo, Brazil

Plant Maintenance Show. July 13–15, 1954, Pan-Pacific Auditorium, Los Angeles, Calif.

Society of Automotive Engineers. West Coast Meeting. August 16–18, 1954, Hotel Statler, Los Angeles, Calif.

West Coast Electronic Manufacturers Association and Institute of Radio Engineers, Los Angeles and San Francisco Sections. West Coast Electronic Show and Convention. August 25–27, 1954, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif.

World Power Conference. Sectional Meeting. July 25–August 10, 1954, Rio de Janeiro, Brazil

Fig. 2 (top). Section of 230-kv Oilostatic circuit showing relative size of pipe and insulated conductors. Fig. 3 (bottom). Cut-back view of 230-kv cable showing details of construction and how piano wire is used to strip temporary lead sheath prior to installation

ture of the system from the earliest days of its development about 20 years ago.

The unique features of this type of installation and the various physical limitations imposed by the topography required more detailed engineering than normally would be required on ordinary types of cable. Studies involved such items as the layout of the piping, the number of bends, the clearances, the type of accessories required, and the pumping plant arrangements.

The steel pipe that is to be used for the 230-kv Cubatao installation is $8^5/_8$ inches outside diameter with an 0.250-inch wall. It is electric weld line pipe made in accordance with the American Petroleum Institute *5L* specification, grade *A* pipe. Both ends of each pipe length (double random lengths averaging approximately 48 feet) are flared to receive a chill ring. This chill ring is used to prevent welding metal from protruding into the inside of the pipe and causing possible cable damage during installation.

The inside of the pipe was hot blasted and given a coat of rust-resistant paint (Bond Kote *#260*) to protect the inside of the pipe during shipment and installation. The outside of the pipe also was shot blasted and coated with coal tar enamel. The flared ends of the pipe were protected during shipment with tapered wooden plugs which also prevent the entrance of foreign matter.

The 230-kv cable which is being manufactured will be 22,281 feet. The maximum length will be 1,530 feet. A total of 15 lengths will be used, three of which are spares. The copper cable will be single conductor 500,000 circular mils, 0.835-inch paper insulation, shielded, with *D*-shaped copper armor wire, and 0.078-inch temporary lead sheath. (See Fig. 2.)

The conductor is concentrically stranded with 61 strands of 0.0905-inch hard drawn bare copper. Two 5/8-inch and one 3/4-inch metallized paper tapes over the conductor provide a smooth conductor desirable in high-voltage cables since this design eliminates points of stress concentration. Approximately 170 paper insulating tapes, graded according to thickness from 0.003 inch to 0.0065 inch, are used. The thinner papers are nearest the conductor to provide optimum impulse strength in this high stress area. An 0.005-inch copper tape is intercalated with 0.020-inch by 0.75-inch woven cotton cloth tape, and 0.102-inch *D*-shaped copper armor wire is applied in an open spiral to protect cable during installation, to provide low coefficient of friction, to space cable away from pipe and adjacent conductors and thus permit oil circulation by thermal movement.

Temporary lead sheath protects cable from moisture during shipment and while stored prior to installation. This 0.078-inch-mil plain lead sheath was applied with a sinusoidal (crimped) piano wire laid under it to facilitate stripping when cables are ultimately pulled into pipe. See Fig. 3.

The 24 potheads and three spares to be used for termination of the Oilostatic cable are of the double tube design, that is, with an internal porcelain tube which provides an envelope for the cable and oil under high pressure and a porcelain weathershed which contains oil at atmospheric pressure between the weathershed and inner tube.

These Ohio Brass potheads were designed for a 900-kv basic insulation level in accordance with all requirements of AIEE Specification *48* pertaining to terminals. These potheads were designed for a test pressure of 500 pounds per square inch (psi). The maximum oil (working) pressure on this installation will be in the order of 275 psi.

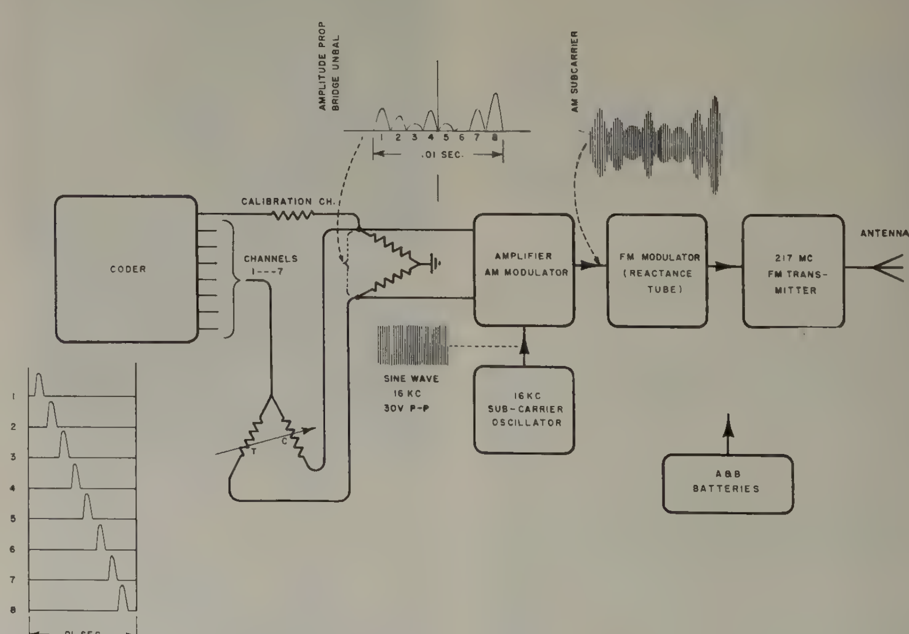
Parachute Telemetering System Facilitates Tests of Experimental Parachutes

A parachute telemetering system recently developed by the National Bureau of Standards (NBS) is facilitating tests of experimental parachutes for use with modern high-speed aircraft. Electronic equipment mounted inside a parachute-borne torso-shaped dummy transmits by radio needed information—altitude, and forces at various points—in coded form to a ground station, where the information is decoded.

In the NBS parachute telemetering system, resistance strain gauges are arranged to sense both altitude (pressure) and the tension in various harness straps. An inductive-commutator arrangement excites one strain gauge at a time, the output of the gauges being combined to modulate a small battery-powered radio transmitter. Seven measurement channels and a calibration channel are provided. At the ground station, a spot on the face of a cathode-ray tube moves up and down with the amplitude of the modulating signal. This spot is recorded on continuously moving photographic film. The film record then is transcribed, using a semiautomatic film reader, to obtain plots of altitude versus time and harness tension versus time.

The air-borne part of the system is designed for ruggedness, low cost, and medium accuracy. Ruggedness is necessary because the period of maximum shock, when the parachute is opening, is the period for which measurements are most important. Low cost is desirable because, with experimental parachutes, occasional losses of equipment are to be expected. Medium accuracy—of the order of 10 per cent—is sufficient, since the phenomena being measured are not reproducible with high uniformity.

The air-borne transmitter operates on 217



Block diagram of the NBS parachute-telemetering system

The air-borne unit of the NBS parachute-telemetering system is housed in a torso-shaped dummy to which the test parachute is attached

mc and has an output of about 0.75 watt and a range of about 2 to 10 miles. Seven tubes are required for the entire air-borne unit. The battery pack, which provides 7.2 volts at 1.0 ampere and 190 volts at 80 milliamperes, is tailored for about 1 hour of service.

The tensiometer which senses forces in the parachute harness is an *H*-shaped steel structure to which resistance-wire strain gauges are cemented. Gauge resistance is 1,500 ohms, and the maximum useful change with harness tension is about 7.5 ohms. The altimeter consists of an evacuated bellows which responds to changes in air pressure by deflecting a thin cantilever beam carrying resistance strain gauges. As both the tensiometer and the altimeter are linear to better than 5 per cent, point-by-point calibration is not needed.

Modulation of the transmitter with the signal from one channel at a time is accomplished by means of a "coder" of novel design. The coder supplies a series of time-sequential pulses to eight resistance bridges—one for the altimeter, one for each of six tensiometers, and one fixed bridge for calibration. One hundred pulses per second are received at each bridge.

The bridge-unbalance signals are first amplified and then converted to amplitude modulation of a 15-kc subcarrier. This subcarrier in turn frequency-modulates the 217-mc transmitter by means of a reactance-tube modulator. A flexible transmitting antenna projects from the top of the dummy that houses all of the electronic equipment.

The ground-station receiver gives an output that is identical to the amplitude-modulated 15-kc subcarrier in the air-borne unit. Demodulator and filter circuits convert this output signal to a waveform identical to the original bridge-unbalance signals. This signal is applied to a cathode-ray oscilloscope and photographed on moving 16-mm film. The output of the ground station is thus a continuous film record of the eight original signals.

To make this record useful, it must be converted to individual curves showing altitude and the various harness tensions against a common time scale. This otherwise time-consuming conversion is expedited by a specially designed film reader. Using this device, the operator adjusts potentiometer-connected mechanical tips to coincide with the signal peaks of the projected film image. When the tips have been so adjusted for one scan of eight channels, the seven information channels are recorded automatically on a strip chart. The recorder chart is advanced automatically, and the entire procedure then is repeated until all information of interest has been transcribed.

Ceilometer Records Changes in Cloud Ceilings Over Runways Almost Instantly

A weather instrument that tells pilots what sort of weather conditions exist over runway approach zones has been introduced by Crouse-Hinds Company, Syracuse, N. Y. The new device, a rotating-beam ceilometer, registers a new cloud ceiling every 6 seconds, enabling control tower personnel to relay almost instantly to incoming aircraft the exact locations and movements of cloud or fog layers.

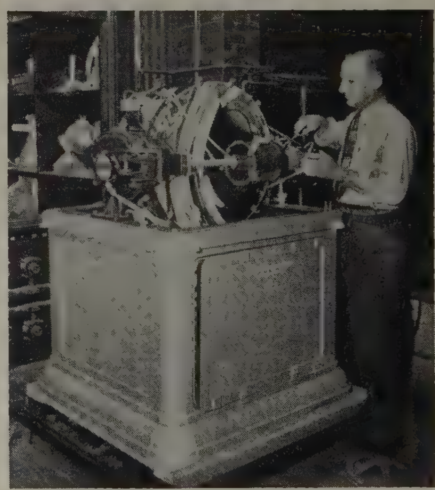
The new ceilometer, together with Crouse-Hinds' transmissometer, are important components of a ground approach landing system, recently developed and tested by the U. S. Weather Bureau.

The transmissometer consists of a projector installed along the runway, which sends a concentrated light beam across a 500-foot span to a receiver. The receiver transforms the beam into an electronic signal. This signal is transmitted to charting equipment at the air field control tower where it is recorded on a strip-type chart, thereby accurately indicating actual runway visibility conditions. The control tower may be located as far as 10 miles away from main runways and still pick up sensitive readings from the transmissometer receiver.

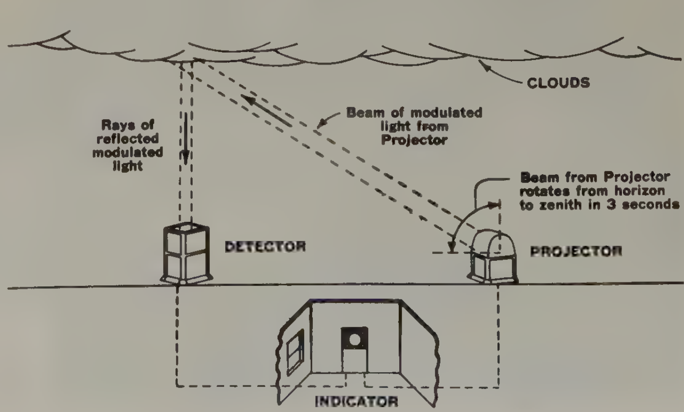
The rotating-beam ceilometer, invented by L. W. Foskett of the U.S. Weather Bureau, is located in the main runway approach zone between the middle marker beacon and the end of the runway. Because it measures the penetration as well as the heights of ceilings, it is an invaluable aid during foul weather. Regardless of the type of ground approach system used, an airport operations center equipped with the new ceilometer has an almost instantaneous record of the heights of cloud layers above the touchdown point. By combining these readings with those of the transmissometer, tower personnel also have an accurate picture of weather above and along the runway and runway approach zone. Thus, a pilot approaching the runway preparing to land, can be given the exact state of weather conditions that he will confront as he lets down his ship.

The new ceilometer consists of two components, a projector and receiver. Employing the customary triangulation method, these units are set along a fixed base line.

The projector consists of a rotating mirror



Projector has rotating assembly that supports two mirrors. To enable the projector light signal to be differentiated from ordinary daylight, a 4-vaned cylindrical shutter, enclosing a lamp, is mounted at the focus of each mirror



Schematic drawing of rotating beam ceilometer

assembly, made up of two 24-inch precision parabolic mirrors that are mounted 180° apart. To enable the projector light signal to be differentiated from ordinary daylight, a 4-vaned cylindrical shutter, enclosing a 250-watt incandescent lamp, is mounted at the focus of each mirror. Each shutter revolves at the rate of 1,800 rpm producing 120 light pulsations per second.

The ceilometer receiver also is equipped with a 24-inch mirror, which faces vertically upward through a watertight glass cover. The mirror's centerline is in the projector's plane of rotation so that a lead sulfide photoconductive cell, located at the mirror's focal point, picks up the pulsating flashes given off by the projector as the light beam is reflected by the cloud ceiling directly overhead. The angle of the projector beam at this instant is transmitted by radio—usually a low-power 2-way commercial system—to the ceilometer indicator which converts the signal into a foot measurement of ceiling height. The indicator is generally located in the airport weather observatory.

Data Processing Machine Is Designed for Office Use

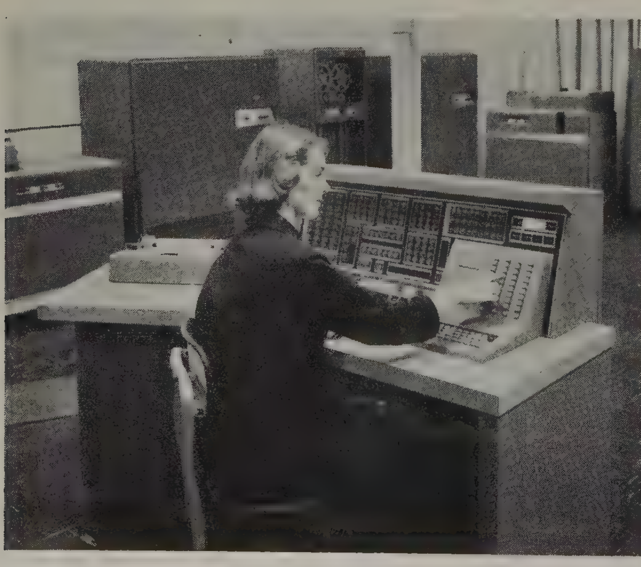
The move toward the "electronic office" gained impetus with the presentation by the International Business Machines Corporation (IBM) of its new type *702* electronic data processing machine before a salesmen's meeting in the Waldorf Astoria.

A high-powered electronic automaton, whose specialty is arithmetic and logic, the *702* was the star of a closed-circuit big-screen telecast from the IBM engineering laboratories in Poughkeepsie, N. Y. Designed for business use, it is said to be the fastest and most flexible commercial data-processing system ever devised.

The *702* is made up of a central arithmetical and logical unit capable of performing more than 10 million operations in an hour. Working partner of this unit is a bank of cathode-ray memory tubes. Reels of magnetic tape, each with a capacity roughly equivalent to all the numbers in the 1,850 pages of the Manhattan, N. Y., telephone directory, feed data to the machine and write down the answers at the rate of 15,000 letters or numbers a second. Punched card readers and punches, and line printers also are provided.

The various units, looking like large grey storage cabinets, are electronically interconnected by cables. IBM engineers say this method of unitized construction simplifies installation and maintenance and provides flexibility in meeting the users' requirements.

The system is controlled by means of a so-called "stored program," which is no more than a finely detailed list of instructions, translated into a language which the machine understands. It retains these instructions in its memory and refers to them, one by one, at lightning-like speed. The actual writing of the instructions and converting them to machine language is said not to be difficult, but the analysis of office operations which is a necessary preliminary step can run into months, or even years, of study. Surprisingly, the logic of commercial problems, considered as a whole, is much more involved than that of scientific ones. This is due primarily to the much greater variety of input and output data and the many exceptions to the rules for handling them.



From this operator's console, supervision is maintained over commercial data-processing operations performed by the 702

New Transformer Standard Promises Savings for Users

By using standardized designs, it is expected that the new American Standard Requirements for Transformers, *C57.12a-1954*, will give users more than \$8,000,000 in savings in the next 3 years. These savings are based on manufacturers' estimates that more than \$100,000,000 in transformers in ratings covered by the standard will be sold during that period. Through quantity production, standardized transformers can be built faster, at costs which will be at least 8 per cent lower than transformers of identical ratings built to individual specifications.

This new American Standard, adopted in January 1954, was completed by the Sectional Committee on Transformers, following its publication in March 1952 as a Proposed American Standard recommended for use. The ratings covered are 501 through 10,000 kva, 3 phase; 501 through 5,000 kva, 1 phase; 67,000 volts and below. The Standard incorporates a number of improvements which have been developed during the interim period in which the Proposed Standard has been in effect.

The major differences between the Proposed Standard and the American Standard were summarized in *The Magazine of Standards* as follows:

A 2,000-kva rating has been included for 3-phase transformers having low-voltage rating of 2,400 or 4,160Y or 4,360Y.

Minimum and maximum temperatures for which the transformers should be suitable were established as a range of top-liquid temperature from −20C to +90C, provided the liquid level has been properly adjusted to the indicated 25C level.

Three-phase transformers, even though Y-connected on the low-voltage side, should be equipped with four low-voltage bushings all of the same voltage class.

Mechanical dimensions for high-voltage bushings in the 25-kv–69-kv class have been established.

In the Proposed Standard the 25C liquid level was stated as being "the distance from the liquid level to a convenient reference point." This is made more specific in the new Standard by establishing this dimension as "the distance from the liquid level to highest point of the handhold or manhole flange surface."

Better uniformity in the way the tap changer positions are numbered or lettered has been established.

A new item is the specification that tanks shall be designed for vacuum filling in the field on all transformers with high-voltage insulation class of 69 kv (350 kv basic impulse insulation level) and on all transformers rated 10,000 kva, any insulation class.

In Part II, the fan-cooled ratings have been modified to provide a fan-cooled rating for the 2,000-kva size of 2,300 kva. In addition, the fan-cooled rating of a 2,500-kva unit has been raised from the previous figure of 2,875 kva to a rating of 3,125 kva.

In Part II the table showing the range of other high-voltage ratings has been slightly modified.

Also in Part II there are considerable classifications made of the available methods of neutral termination of Y-connected windings.

Several additions have been made in terminal board arrangements in Part II to provide for those users who are unable to utilize standard phase displacements.

The new Standard contains detailed information on name plates, developed by the National Electrical Manufacturers Association, as an appendix.

Signal Corps Exhibits Latest Communication Equipment

How a single Army Signal Corps communications line can handle hundreds of messages at one time was shown to the public at the Eighth Annual Convention of the Armed Forces Communications Association in the Shoreham Hotel, Washington, D. C., May 6 and 7, 1954.

The public also was invited to try for themselves more than 150 new Signal Corps radio and wire equipments set up in the west

lobby leading to the convention registration desk. The equipment was in live operation exactly as in combat where it provides rapid communications between army, corps, division, and regimental levels.

The Signal Corps also demonstrated in action several experimental devices showing major reduction in size and weight by using transistors and the printed circuits which eliminate complex wiring.

One of these was the "Dick Tracy" wrist radio, which picks up broadcasts from *WTOP*, *WWDC*, and other Washington radio stations. The whole radio is inside a plexiglass case 2 inches long, $1^1/_8$ inches wide, and 3/4 inch thick.

The public also saw and heard a public address system powered by a 4-ounce amplifier, the sound of which can easily fill a 20- by 50-foot room; used headphones for tuning a radio; and heard their voices amplified over an Army telephone circuit.

Rounding out the Signal Corps display were high-powered radar tubes, a large mock-up of a transistor, and many advances in military photography. These included a camera with 100-inch lens which detects a jeep 6 miles away; a phosphorographic camera using infrared to project a positive picture; synchronized motion picture projectors and audio tapes; and progress of the past 3 years in producing on-the-spot pictures with invisible electrical images and improving picture sharpness at least 25 times with a photo processing method that requires no washing of films and prints.

The carrier communications exhibit centered about a pair of new Signal Corps wire systems, the 12-channel and the 4-channel.

The Signal Corps' new carrier communications system can eliminate or by-pass cables by using radio. Instead of feeding messages into the spiral-four, they are fed into new radio-relay equipment which can then hop, via the air waves, over ravines, rivers, and gullies.

The larger radio relay link replaces five older radios. It has a simple 1-knob control instantly tuning in any one of 758 separate frequency channels. In the older set, changing a channel meant changing crystals and trained specialists to realign the equipment.

The new smaller radio relay set gives the Army, for the first time, mobile radio-relay facilities at division level and below. Formerly these equipments had to be set up in fixed ground position. The set is designed for vehicular use, and by spacing vehicles every 25 miles apart, multichannel radio communications are quickly set up or broken down to keep pace with fluid battle conditions.

Passenger Belt Conveyor Placed in Operation

The world's first passenger belt conveyor has been placed in operation by the Hudson and Manhattan Railroad, Jersey City, N. J. Designed by the Goodyear Tire and Rubber Company and the Stephens-Adamson Manufacturing Company, the "Speedwalk" has been installed by the railroad in its Erie tube station to transport New Jersey commuters for a distance of 227 feet up an inclined ramp leading to the Erie railroad terminal. The moving rubber belt passenger conveyor negotiates a 10-per-cent grade for the first 137 feet.

Looking upgrade (10 per cent) of 227-foot Speedwalk, moving handrails being installed at both sides

Operating at a speed of 120 feet a minute, the belt will deliver passengers who walk along its moving surface to the end of the ramp in 35 seconds, compared with a normal upgrade walking time of 55 seconds through the regular passageway.

Five and one-half feet wide and with moving handrails, the belt conveyor utilizes only approximately half of the regular ramp tunnel, leaving a walkway alongside. Hudson and Manhattan officials announced that the belt, which is reversible, will be operated only upgrade for the present between the hours of 7 a.m. to 7 p.m. A 20-hp electric motor drives the endless belt which rides along a bed of closely spaced steel rollers or idlers.

Hudson and Manhattan work crews, under the direction of W. A. Davis, general superintendent, spent a month installing the 30 tons of conveyor equipment and machinery which was fabricated at the Stephens-Adamson plant in Aurora, Ill., and threading the 11,000-pound rubber and fabric belt made by Goodyear in Akron, Ohio. The belt is 5/8 inch thick and was manufactured as a single unit 460 feet long. Goodyear engineers vulcanized the two ends together after the belt was threaded through the end pulleys and placed on the conveyor frame work.

The Speedwalk can handle 10,800 passengers an hour in a single direction at a speed of $1^1/_2$ miles an hour. Only about 9,000 commuters now use the Erie tube station daily.

Speedwalk head pulleys and gears, 20-hp motor at top left drives 460-foot belt at 120 feet per minute

TV Promises Top Command Control of Battle Action

Promise of the first means in military history for comprehensive "top command" control of battle action is seen in the experience obtained thus far with the Signal Corps Mobile Television System, it was disclosed recently at the 75th semiannual convention of the Society of Motion Picture and Television Engineers in Washington, D. C. Captain H. C. Oppenheimer, Chief, Television Branch, Army Pictorial Service, described the recent use of the system as an operational part of the Army's "Exercise Flashburn" maneuver at Fort Bragg, N. C.

"Since the first wars were fought," Captain Oppenheimer said, "military leaders have been hampered by their inability to see what was taking place on the battlefield. Plans had to be based on fragmentary and often contradictory reports from scouts and patrols. Control during the actual battle presented even a greater problem with success left in the hands of the small unit commanders.

"With the slow, steady, development of battlefield communication systems, starting with signal fires and flags and progressing to telegraph, telephone, and radio, some measure of control became possible and the commander was able to form a picture, not always accurate, of the local and over-all situation. His picture, of necessity, depended upon the experience, judgment, and interpretation of many, and was sometimes hours or even days old by the time it reached him. In the future of television may lie the answer: the ability to see immediately and control the battle situation."

When first obtained from Radio Corporation of America, the Signal Corps television equipment was installed in vans. On the basis of early experience, Captain Oppenheimer reported, the vans were converted to tractor trailers. In addition, he said, the initial equipment was supplemented by an air-borne television system and a fifth land

vehicle, containing air-ground receivers and kinescope facilities.

Results favoring the effectiveness of instruction by television were obtained, he reported, also, in an experimental program involving 43 companies of trainees and 103 different training and testing situations. In this study, 56 hours of television instruction, with parallel regular instruction, were given over a period of 2 months, with some 10,000 trainees taking a total of about 70,000 tests. The advantage of television was particularly evident, Captain Oppenheimer said, in the "how-to-do-it" type of instruction, such as the assembly or disassembly of a weapon and instruction incorporating the cue and response technique.

Applications explored with the mobile television unit, he said have included: 1. location, evaluation, and designation of artillery targets; 2. adjustment and control of artillery fire; 3. data transmission; 4. intelligence and reconnaissance; 5. briefing tactical commanders; and 6. observation and control of amphibious landings, river crossings, and assaults, and harbor surveillance.

New Grumman Plant Has $2,000,000 Electric System

The mammoth Peconic River plant near Calverton, L. I., which the Navy has completed for Grumman Aircraft Engineering Corporation, has an electric system adequate for a small city, it was announced by Sidney P. Lipkins, president of Broadway Maintenance Corporation. Broadway Maintenance in co-operation with Charles A. Mulligan, Inc., handled the complete electric installation which involves 3 miles of 66,000-volt transmission line, an outdoor 66,000- to 13,000-volt step-down substation, 13,000-volt switchgear and underground cables, 12 13,000-volt indoor distribution substations, and all interior wiring for light and power.

Exterior of 7-section hangar door

Located about 75 miles from Manhattan on a 4,500-acre tract, the new Grumman layout includes an assembly-administration building, a steam heating plant, a paint shop, a flight operations building, hangars, and warehouses. This is the first aircraft plant to be built solely for jet assembly and flight operation. With its two runways, one 10,000 feet and one 7,000 feet long, the Calverton installation is conceded to be one of the world's great military flight centers.

Doors for the hangars consist of seven separate and independently controlled sections, each weighing 6 tons and measuring 20 feet wide by 36 feet high by 8 inches thick. Seven paralleled floor rails permit movement of one or more of the sections to open or closed positions at will. Each section has a push-button control for actuating a built-in 1-hp motor with gear-drive mechanism. When the hangar is completely closed, the sections overlap slightly; when the hangar is completely open, the sections are stacked together at one side of the building.

The hangar section of the assembly building is built to accommodate a large number of completed planes. The power supply system for this area is installed in pits which run lengthwise of the building. Because of the presence of high-octane fuel, all electric equipment is explosion-proof at levels 3 feet above the floor and below.

Bus duct is used in certain areas of the assembly plant to accommodate 120/208- and 440-volt power supply requirements. Openings spaced 1 foot apart along the bus duct make it easy to change tap-off connections to suit new manufacturing situations.

Fluorescent lighting is employed in the assembly areas and fixtures are mounted directly above the traveling cranes. Each crane is provided with a hanging basket designed specifically to accommodate a man and the equipment he needs for lighting maintenance work. Engineering design provides a maintained lighting intensity level of 35 foot-candles in the hangar assembly area.

The outdoor 66,000- to 13,000-volt step-down substation is rated 6,250 kva with fan cooling. The indoor distribution substations have various ratings ranging from 500 to 150 kva, all are of unitized, fully enclosed design with associated switchgear and metering panels. Some of these indoor substations are utilized in the air-conditioning system as plenum chambers.

ECPD Completes Survey on Awarding Professional Degrees

The Recognition Committee of the Engineers' Council for Professional Development, under the chairmanship of R. H. Barclay (F'28), has completed a survey of the awarding of the professional degree by various engineering institutions. The survey with its excellent response—of the 146 institutions sent questionnaires, 142 responded—will serve as a basis for formulating recommendations concerning the practice of awarding the professional degree as a means of professional recognition.

Of the engineering schools surveyed, 86 award the professional degree while 62 do not. Of the 86 awarding the degree, 74 use professional experience as a basis for awarding the degree, 8 require resident graduate study, and 4 include both professional experience and resident graduate study as prerequisites for awarding the professional degree.

In regard to their future plans concerning the professional degree, 69 colleges will continue awarding the degree, 2 will institute the professional degree, 13 will abandon it, 49 will continue not to award it, and 17 are uncertain as far as future plans are concerned. The survey shows that approximately one fifth of the schools offering the professional degree either have dropped it or are making plans to do so.

The committee also reported an increase of approximately 80 per cent in the awarding of professional degrees in the last 5 years as compared with the previous 5-year period. In the last 10 years, 1,387 to 1,398 professional degrees have been awarded, and of these, 917 to 922 have been awarded during the last 5 years.

The committee believes this survey to be the most comprehensive of its type ever undertaken and will use it in formulating recommendations on the practice which they believe should be followed in respect to awarding the professional degree as a means of professional recognition.

Human Engineering Institute Stresses Man-Machine Relation

A 5-day Human Engineering Institute was conducted by Dunlap and Associates, Inc., May 10–14, 1954, in Stamford, Conn., for a group of engineers concerned with military and industrial design.

Stressing the relationship between the man and the machine he operates, the many factors which go into the smooth functioning of a system were considered. Such topics as "Body Responses," "Proper Design of Instrument Displays," "Use of Data on Body Dimensions," "Layout of Work Places," "The Working Environment," and "Man-Machine Dynamics" typify the scope of the phases covered.

The final session was devoted to industrial applications and the guest speakers stressed the fact that physiological and psychological consideration must be given to the design of any man-machine system if the system is to be successful to any great degree.

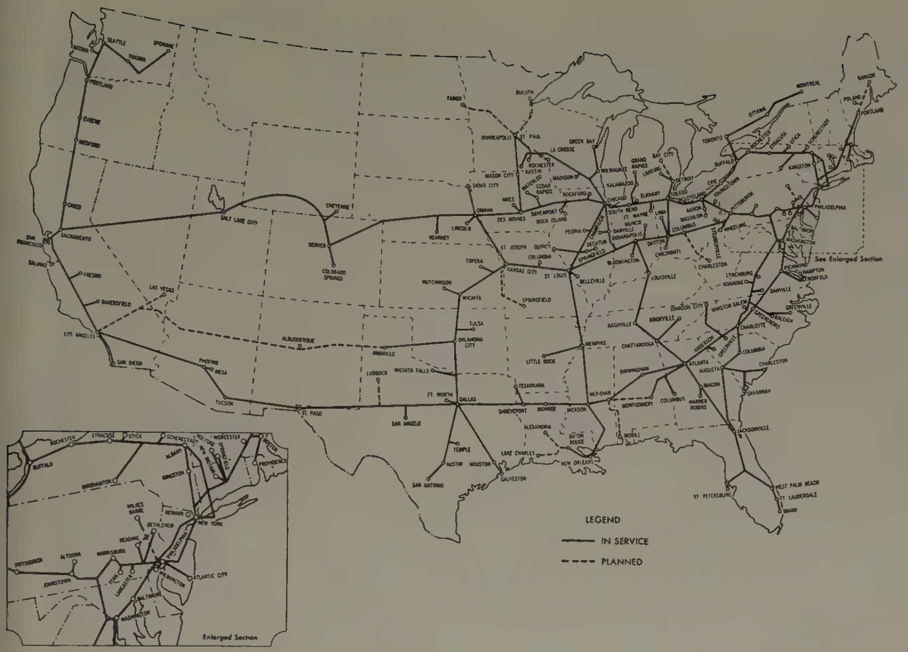
300 Television Stations Now Receive Network Service

Three hundred television stations over the nation are now receiving network service.

The 300th station to be linked for network service was *WKNY-TV*, Kingston, N. Y. It was connected to the Bell System's nationwide network of television facilities recently via local installation provided by the New York Telephone Company.

WKNY-TV, the first television station for Kingston, began receiving network programs over the New York–Albany communications route of the Bell System.

The Long Lines Department of American Telephone and Telegraph Company, which



Bell System television network routes, May 1954

provides transmission facilities that tie radio and telephone systems as well as television into national networks, said the interconnection brought the rollcall on network television service to 191 cities in the United States.

More than 54,000 channel miles of coaxial cable and radio relay facilities are being used to provide these cities with network television.

There are now about 380 television stations on the air in the United States. These stations, located in some 250 cities, broadcast to an estimated potential audience of 109,000,000.

Long Lines said that before the year is out about 60 more television stations are expected to be added to network facilities.

Six years ago, when network television was inaugurated commercially, there were fewer than 1,000 miles of television channels in operation. These linked 12 stations in five cities: Boston, New York, Philadelphia, Baltimore, and Washington.

By the end of 1948, the embryo network facilities had been extended to 31 stations in 15 cities. During each of the next 4 years, an average of 7,000 channel miles was added.

Thus far in 1954, 55 stations have been added to the network list, maintaining the rate of almost three stations a week that marked 1953 as a record year of growth for network television.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

The Bewildering Decibel

To the Editor:

The article entitled "The Bewildering Decibel" (*EE, Jun '54, pp 550–5*) is an excellent treatment of the question of a suitable logarithmic unit for general scientific and engineering purposes. It does, however, raise a few questions.

The value of the unit proposed would be a ratio of 1.259/1. It would seem that a value approaching more closely a 10-per-cent increment per step, such as would result from a base of 10^{-20} instead of 10^{-10}, would be of greater practical value. This question is discussed in correspondence entitled "Preferred Numbers" published in the December 1951 issue of the *Proceedings* of the Institute of Radio Engineers.

It would seem, also, that any such unit and name for general scientific and engineering use should not leave any ambiguity, or implication thereof, as to whether the Briggs or the Naperian logarithmic system is the basis of the "logit" logarithmic unit.

It is interesting to note that the "Neper" is based on voltage and current ratios—not on power ratios.

Why not the Brigg and the deci-Brigg (dbg)? Or, if an arbitrary "unit" is desired, make it the 1/20 power of 10. That is, 10^{-22} or 1.122/1; this ratio being of greater practical usefulness than 10^{-10} or 1.259/1.

JOHN B. MOORE (M'41)

(RCA Communications, Inc., New York, N. Y.)

To the Editor:

The treatise on "The Bewildering Decibel" must have gotten in on the merit of the idea and not on the merit of the article.

Certainly the transmission unit is not sacred and *is* dimensionless unless ordinary efficiency has some obscure dimensions.

Certainly it makes no difference whether a ratio is described in terms of the log of that ratio to the base tenth root of 10 or 10 times the log to the base 10. The answer is the same.

Certainly it is astonishing to find so many words used to describe a few simple ideas.

But it is also certain that the author is absolutely correct that muddy thinkers and careless writers have obscured and confused the connotations of the word "decibel" and yet that there is need for a pure ratio unit. His idea of getting a new start with his new word "logit" seems sound.

As he points out, there are two separate and distinct uses for such a ratio unit. One is in describing large and small quantities of any dimensional unit and the other is in describing ratios without reference to absolute magnitude. Thus, a power line voltage of 1,000 volts might be spoken of as 30-volt logits and an amplifier voltage gain of 1,000 from, say, 1 millivolt to 1 volt (or from 100 millivolts to 100 volts) might be described as 30 logits voltage gain. If the resistive input impedance is 100,000 ohms and the output load 10,000 ohms this same amplifier has 70 logits power gain.

If writers can manage to keep the two usages separate, his ratio unit, the logit, can be very useful both in ratio calculations such as compound interest, cascaded efficiencies, and voltage and power amplifiers, and in describing large and small quantities of things.

The mass of an electron might be (but is not) negative 150 gram logits. A national appropriation of 10 billion dollars would be 100 dollar logits.

STANLEY R. JORDAN (AM'37)

(15–28 Meriline Avenue, Dayton, Ohio)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

THERMIONIC VALVES. By A. H. W. Beck. Cambridge University Press, 32 East 57th Street, New York 27, N. Y., 1953. 570 pages, $8^3/_4$ by $5^3/_4$ inches, bound. $12. A comprehensive, theoretical account of the behavior of thermionic high-vacuum devices, intended as an introduction to current research and a reference work for the practicing engineer. The first of three parts deals with the fundamental physics of thermionic emission; the second considers the general theory of fields and electron motions related to charged conductors; and the last and longest section applies this material to various classes of tubes. Microwave tubes receive special attention.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

CONTRIBUTION A L'ÉTUDE DE LA COURBEE DE RÉSONANCE D'UN QUARTZ. By Jean Coulon. France, Ministère de l'Air, Publications Scientifiques et Techniques (Notes Technique, no. 47) Paris, France, 1953. 55 pages, $11^3/_4$ by 7 inches, paper. Ffrs. 450. A study of the resonance curve for quartz, with particular reference to its application in detection and frequency stabilization.

ELECTRICAL REFRESHER FOR PROFESSIONAL ENGINEERS LICENSE. By John D. Constance, 625 Hudson Terrace, Cliffside Park, N. J., second edition, 1954. Various paging, $8^1/_2$ by 11 inches, paper. $3. This survey of fundamentals, illustrated by selected problems from past examinations, is intended for candidates for professional licenses, civil service positions, etc. Topics covered include electric equipment, generators, motors, transmission, measurement, and others. Use as an office reference manual is also suggested by the author.

ELEMENTS OF ELECTRICAL MACHINE DESIGN. By Alfred Still and Charles S. Siskind. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., third edition, 1954. 445 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $9. A revision of the 1932 "Elements of Electrical Design," from which material not related to rotating electric machinery and transformers has been dropped. In treating the design principles of d-c and a-c generators, induction motors, and transformers, materials and their arrangement are discussed first, and then follows derivation of design formulas and the solution of illustrative examples. There have been considerable additions and rearrangements of material, and there is a new chapter on mechanical features of electric machine design.

ÉTUDE DU MÉCANISME DE LA PULVÉRISATION DES SOLUTIONS ÉLECTROLYTIQUES PAR L'ÉTINCELLE ANODIQUE. By Pierre Barret. France, Ministère del 'Air, Publications Scientifiques et Techniques (Notes Techniques, no. 48) Paris, France, 1953. 94 pages, $10^3/_4$ by $7^1/_4$ inches, paper. Ffrs. 700. Experimental and theoretical analysis of the phenomenon of atomization of an electrolytic solution by means of an electric spark from a wire acting as the anode to the solution acting as the cathode. The effect of different electrolytes and other varying conditions is discussed.

HISTORY OF AMERICAN INDUSTRIAL SCIENCE. By Courtney Robert Hall. Library Publishers, 8 West 40th Street, New York 18, N. Y., 1954. 453 pages, $8^3/_4$ by $5^3/_4$ inches, bound. $4.95. Essentially a history of the development of American industry from colonial times, this new book emphasizes the increasingly larger part played by scientific research in all lines. It deals with land, water, and air transportation; electrical and communication industries; mining and metallurgy; the chemical field, rubber, pulp, paper, and print; and agriculture. Separate chapters are devoted to business machines and precision instruments and to the relation between industrial science and national defense.

THE INSTRUMENT MANUAL. United Trade Press Ltd., London, England, second edition, 1953. 628 pages, 11 by 9 inches, bound. £ 4.4.0. A review of British instrumentation covering a wide range of apparatus for observing, measuring, recording, and control. Various classes of instruments—ranging from engineering precision instruments to nucleonic instruments—are described in 25 sections, and there are lists of instrumentation organizations, publications, and manufacturers. A combined index is provided.

THUNDERSTORM ELECTRICITY. Edited by Horace R. Byers. University of Chicago Press, 5750 Ellis Avenue, Chicago 73, Ill., 1953. 344 pages, $9^3/_4$ by 7 inches, bound. $6. This collection of articles by specialists, mainly from a conference on thunderstorm electricity held in 1950, summarizes the latest knowledge of the electricity and structure of thunderstorms, their role in the electrical balance of the world, and the nature of their electric charge. In addition to theoretical papers, practical problems of long-distance location of storms, aircraft and lighting, and power-line protection are discussed.

LE TITANE ET SES COMPOSÉS DANS L'INDUSTRIE. By Maurice Déribéré. Dunod, Paris, France, second edition, 1954. 276 pages, $8^1/_2$ by $5^1/_4$ inches, paper. Ffrs. 1,650. A manual for engineers and executives in industries using titanium. The book reviews the sources of the metal, its properties and those of its compounds, the metallurgy of ductile titanium, and the preparation and characteristics of titanium pigments. The second section describes various uses of titanium in such industries as paints, synthetic textiles, plastics, and the electrical industry. A list of patents from various countries is included.

WELDING ENGINEERING. By Boniface E. Rossi. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1953. 786 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $8. This comprehensive survey of welding engineering provides fundamentals for the student or beginner and a wider understanding for those now in the field. It can be used also as a reference manual by engineers, designers, and others. The four main sections of the book cover welding processes, metals and their weldability, design and fabrication considerations, and testing and inspection of welds.

BATTERY CHARGERS AND CHARGING. By Robert A. Harvey. Iliffe and Sons, Ltd., London, England, 1953. 400 pages, $8^3/_4$ by $5^3/_4$ inches, bound. 35s. The construction and chemistry of all types of storage batteries are explained, followed by the fundamental principles of charging together with much general information on charging technique. The book then describes how those principles apply in a wide range of specialized applications: electric vehicles and locomotives, emergency lighting and power systems, telephone exchanges, mines, ships, aircraft, cars, and isolated buildings. Home chargers and commercial charging arrangements are dealt with in detail.

METALLURGY OF WELDING. By Walter H. Bruckner. Pitman Publishing Corporation, 2 West 45th Street, New York 36, N. Y., 1954. 290 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $6. As this text emphasizes the metallurgical aspects and problems of welding, it should be of interest to the engineer and metallurgist. It first covers heat flow in metals, welding methods, and brazing. Other subjects covered are surface treatments; specifications for base metals, electrodes, and welding rods; weldability; and the economics of welding and design. References are listed after each chapter, and appendixes give a review of metallurgical principles and additional bibliography.

N.F.P.A. HANDBOOK OF FIRE PROTECTION Robert S. Moulton, editor. National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass., 11th edition, 1954. 1,560 pages, $7^3/_4$ by $5^1/_4$ inches, bound. $10.50. Essential information on methods of fire prevention and protection that have stood the test of time are compiled in compact form in the present edition of this handbook. New data have been added and obsolete material has been revised. There are new and revised tables of fire hazard properties of chemicals and solvents and other hazardous materials, new automatic spray sprinklers now are treated in detail, and material on combustible finish materials has been revised considerably.

NATIONAL ELECTRICAL CODE, 1953 edition. (National Fire Codes, volume V.) National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass., 1953. 576 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $3. The 1953 edition of the National Electrical Code replaces all previous editions and supplements. Basic minimum requirements for safety are defined for electric conductors and equipment used for light, heat, power, radio, signaling, and other purposes. There are chapters on general applications; on installations involving special occupancies, equipment, etc.; on installations of communication systems; and on construction specifications. A separate section gives electrical provisions of other National Fire Protection Association standards.

PAMPHLETS • • • • •

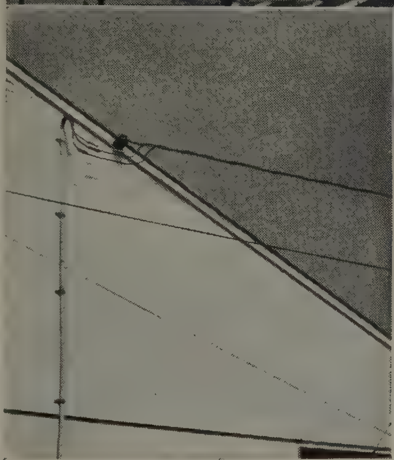
The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Tables of the Exponential Function e^x. Part of the Applied Mathematics Series prepared by the National Bureau of Standards's Computation Laboratory, this volume presents in nine sets of tables the values of ascending and descending exponentials of e^x, tabulated to 12, 15, and 18 decimal places. These tables are understood to be correct to within $^1/_2$ unit in the last decimal. This volume of mathematical tables should be of particular interest to those scientists working in the fields of classical and modern physics and physical chemistry. 540 pages, with tables. $3.75. Order from Superintendent of Documents, Government Printing Office, Washington, D. C.

Automatic Impedance Recorder for X-Band. This volume presents diagrams, circuit designs, and pictures of assembled and disassembled components of a broadband, low-power, automatic impedance recorder developed for the X-band frequency range. It will accept any impedance which has an X-band waveguide input and will plot an ink graph of either the impedance or the admittance upon a standard chart. 36 pages, with photographs, charts, and bandwidth plots. $1.00. Available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

Styroflex Coaxial Cable. A new kind of coaxial cable transmission line (Styroflex cable) adapted for use in field experiments by the Naval Research Laboratory has cut installation time and costs. The new coaxial cable features a continuous helix of polystyrene tapes in place of the conventional bead spacers, and an extruded soft aluminum sheath instead of drawn copper tubing. The report also illustrates devices for handling Styroflex cable in both open-trench and conduit installations and gives details of fittings developed for connecting the cable to standard fittings. 30 pages, with photographs, diagrams, and tables. 75¢. Available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

A Magnetic Amplifier for Synchros. Important savings in space and weight may be offered by a new type of magnetic amplifier that will position a large number of synchro motors from the signal of a single synchro generator. Positioning is achieved by a completely static coupling without the use of control transformers as error-sensing devices, or of servo motors and follow-up mechanism. The new magnetic amplifier is said to be lighter, smaller, and far more reliable than the electronic amplifier system currently in use for multiple shaft-positioning from a remote synchro generator. 18 pages, with diagrams and charts. 50¢. Available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.



Wire assembly is anchored to house and pole by the bare neutral. Older method required anchoring three wires, cost more in time and material.

33% LESS WEIGHT FOR DROP WIRE

BAKELITE Polyethylene covering on Aluminum Wire means easy handling, fast installation

Weight is no problem with the 90-foot spans of service drop wire illustrated, as used by The Ohio Power Co. One man easily carries a 500-foot coil of this wire. Its two 7-strand No. 4 aluminum conductors are covered with a minimum two sixty-fourths inch of BAKELITE Polyethylene, the lightest commercial plastic. Result—33% less weight than wire with a covering formerly used.

The bare neutral supports the whole assembly. It's the only wire anchored, so installation is simpler and more economical than with older types. Conductors are free of tension.

Several additional advantages may be expected for wire and cable applications where BAKELITE Polyethylene is employed as covering. Tests on the black compound indicate a service life of several decades. It won't festoon. It resists moisture, oil, most strong acids, alkalies, and mildew, stays tough and flexible at –70 deg. C. and resists deformation at temperatures around 90 deg. C. It can be used in thinner wall sections, making pulling and stripping easier.

Ask your cable supplier for complete details on wire and cable covered with BAKELITE Polyethylene, or write Dept. YB-66 for a list of representative suppliers.

One man can easily carry 500 feet of this drop wire covered with BAKELITE Polyethylene.

BAKELITE
TRADE-MARK
Polyethylene
FOR WIRE COVERING

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N.Y.
In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

INDUSTRIAL NOTES ....

General Electric News. A major advance in electrical manufacturing was noted May 11, 1954, as General Electric's new \$25,000,000 plant at Rome, Ga., first facility to be built for mass production of power transformers, was officially opened and dedicated. With nearly a half mile of conveyors, new processes, and new machinery, the company has succeeded in reducing by more than one third, the manufacturing cycle for this size of transformers.

The plastics department has created an operations research section within its management group. K. O. William Sandberg has been named manager of this new group. Dr. Sandberg will be located at department headquarters in Pittsfield, Mass.

Frederic H. Holt, of Schenectady, N. Y., has been appointed general manager of the appliance control department. Headquarters for the department are at Morrison, Ill.

Fred M. Pugh has been appointed manager, Midwestern sales district of the company's silicone products department. In his present assignment as Midwestern sales district manager, Mr. Pugh will be located at 1105 Chester Avenue, Cleveland, Ohio.

Jack E. Bolt has been appointed application engineer in the phenolics engineering unit, chemical materials department of the company's Chemical Division.

Three new sales managers have been appointed in the communications equipment unit of the company's electric commercial equipment department in Syracuse, N. Y. Neal F. Harmon was named sales manager for mobile communication equipment; Edwin W. Kenefake, sales manager for microwave equipment; and James D. Helm, sales manager for special accounts. The three men will make their headquarters at Electronics Park in Syracuse, N. Y., and will report to L. Robert Sheeley, manager of sales for communication equipment.

John M. Witzel has been named supervisor, electrical insulating materials unit of the company's alkyd products engineering section, chemical materials department. Dr. Witzel's headquarters will be at 1 River Road, Schenectady, N. Y.

Robert B. Young has been appointed supervisor, advance development unit of the company's alkyd products engineering, chemical materials department. Dr. Young's headquarters will be in Building 77 at 1 River Road.

Westinghouse Notes. The Westinghouse Electric Corporation broke ground at Blairsville, Pa., on May 3 for its new multimillion dollar metals plant. Work has begun on construction of the new facility at a site about 45 miles east of Pittsburgh, Pa.

M. S. Strickler has been appointed manager of the new General Products Division of Westinghouse Electric International Company.

Robert A. Neal, Pacific Coast vice-president, retired April 30 after 44 years of service with the company. Mr. Neal, whose headquarters were in San Francisco, had directed western operations of the company since Westinghouse acquired the Sunnyvale manufacturing plant 7 years ago.

The new Duluth, Minn., plant has been completed and is ready for business. The 140-foot-long building is located at 9320 Grand Avenue on Route 23 and is equipped to repair, rebuild, or manufacture parts for any heavy electric product. L. T. Williams has been appointed manager of the plant.

Donald C. Burnham has joined Westinghouse as vice-president in charge of manufacturing. He suceeds T. I. Phillips, who is retiring after 39 years of service.

U. S. Steel Plans. With the sale of $7^1/_2$ acres of City of Cleveland (Ohio) property at the foot of East 42d Street and Harvard Avenue, to American Steel and Wire Division of United States Steel Corporation, construction of the new rod mill has begun. The new facilities will include a combination rod mill, billet storage area, and rod storage area.

The National Tube Division of United States Steel Corporation has announced that it will begin installation of equipment for the manufacture of plastic pipe. This division has been experimenting with a pilot plant manufacturing plastic pipe since late 1952 at McKeesport, Pa., and additional development work will be continued on improved thermoplastic materials, as well as on reinforced thermosetting types of plastics.

Anniversary Book. The Tung-Sol Electric Company, Inc., Newark, N. J., has issued a 60-page illustrated book upon the occasion of the 50th anniversary of the establishment of the company.

IRC Changes Name of California Subsidiary. International Resistance Company has announced that its wholly owned California subsidiary, formerly the Gorman Manufacturing Company, will now be known as Ircal Industries. Edward A. Stevens, vice-president and treasurer, has been elected president of the Los Angeles concern. Purchased in June of 1953, Ircal Industries is specializing in the manufacture of encapsulated wire-wound precision resistors.

New Plant. Leeds and Northrup Company plans to construct a modern instrument plant on a 129-acre tract adjacent to North Wales, Pa. Construction is planned for early fall, with occupancy in latter 1955. Approximately 1,300 of the firm's 3,100 employees will be at the new location. The new plant will not replace the long-established headquarters at 4901

(*Continued on page 24A*)

(*Continued from page 18A*)

Stenton Avenue and other properties in the Germantown section of Philadelphia.

Electronic Boom in Puerto Rico. Puerto Rico's 10-year tax exemption holiday for new industries has attracted 30 electronic plants to the Island during the past 6 years. Latest to join the "Operation Bootstrap" hegira is the Weston Electrical Instrument Corporation of Newark, N. J.

Vitro Appointment. Vitro Corporation of America has appointed Glen W. Wensch to be the metallurgical engineering representative of the corporation in the atomic power reactor project now under study by 26 associated firms, led by Dow Chemical Company and Detroit Edison Company.

Bendix Promotes Two on TV Staff. C. M. Granger, formerly assistant to the general manager, has been promoted to general factory manager of the television division; and Kenneth Brown, formerly field service chief, has been promoted to television service manager at the Bendix Aviation Corporation.

Magnecord Appointments. The appointments of Roy Witte as chief mechanical engineer and William F. Boyland as chief electronic engineer for Magnecord, Inc., has been announced.

Kollsman Representatives. As part of an expanding customer relations program at Kollsman Instrument Corporation, Robert L. Peavy, John C. Hebron, and Paul T. Grant have been appointed contract engineering representatives. Kollsman Instrument Corporation, manufacturers of precision aircraft and optical instruments and systems, is a wholly owned subsidiary of Standard Coil Products Company, Inc.

Vice - President Named. Richard C. Lipps has been appointed vice-president in charge of marketing for the Roller-Smith Corporation, Bethlehem, Pa. Mr. Lipps was formerly with General Electric Company, where he was Eastern regional manager of the Trumbull Electric Department, Plainville, Conn.

Porcelain Products Promotion. The High-Voltage Division of Porcelain Products, Inc., has announced the promotion of Harold Elliott to the position of sales manager of this division, with headquarters in Parkersburg, W. Va.

Daystrom Vice-President. Howard J. Warnken has been appointed vice-president of Daystrom Instrument, a Division of Daystrom Incorporated. In his new capacity, he will continue to direct contract negotiations between Daystrom Instrument and the Armed Forces, as well as the company's sales program for contracts in private industry.

(*Continued on page 30A*)

R & I E RESEARCH and DEVELOPMENT

Looking out for your future—over the present high voltage horizon. That is the program of R&IE Research and Development. Here, we are determining factors associated with 500 Kv designs: —adequate and economical insulation, proper break distance, effective corona shielding, safe, dependable, all-weather operation and general refinement of details.

When your system operation indicates voltage levels beyond 230 Kv, and even beyond 330 Kv, these data and our engineers are available for assistance in your planning. Send us your problem.

R&IE SWITCHING EQUIPMENT

DIVISION OF I-T-E CIRCUIT BREAKER CO., GREENSBURG, PA.

One of the many development tests on the Type TTR49

(*Continued from page 24A*)

Sales Engineer Transferred. Thomas B. Preston, sales engineer with the Mechanical Goods Division, United States Rubber Company, has been transferred to Los Angeles, Calif., where he will take charge of grinding wheels sales for the Pacific Coast. He will make his new headquarters in the company's Los Angeles branch at Soto and East 46th Streets.

New Allis - Chalmers Posts. Appointments of two Allis-Chalmers Manufacturing Company's regional representatives for steam turbines and power plant equipment has been announced. They are C. C. Jordan, representing the Northwest and Midwest regions with headquarters in the Milwaukee, Wis., district office, and W. B. Tucker, assigned to the company's Central regional office at Cleveland, Ohio.

Two New Sales Offices. Establishment of two new sales offices of the technical sales department will be physically located directly at the Allen B. Du Mont Laboratories plant that manufactures the products sold by that office. One office will be located at Du Mont's cathode-ray tube plant at 750 Bloomfield Avenue, Clifton, N. J. It will be headed by Daniel Echo. The other office will be located at Du Mont's tube manufacturing facilities at 2 Main Avenue, Passaic, N. J., where industrial cathode-ray tubes and multiplier phototubes are made. This office will be headed by Robert H. Dolbear.

NEW PRODUCTS • •

Recorders. Two new electronic strip chart recording instruments designed to record 10 and 20 points have been introduced by the Industrial Division of Minneapolis-Honeywell Regulator Company. The new 20-point strip chart recorder yields 25 per cent more data than 16-point recorders, without proportionate increase in either size or maintenance expenses. For further information request Specification Sheet *165.1* from Minneapolis-Honeywell Regulator Company, Industrial Division, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Miniature Transformers. Recent announcement by the Audio Development Company, Minneapolis, Minn., covers a new line of miniature hermetically sealed transformers and chokes. Suitable for use in circuitry such as geophysical or transistor application, these compact transformers and chokes measure only 3/4 by 15/16 by $1^7/_8$ inches high. They are available in both standard steel and mu metal. For additional information address inquiries to: Industrial Sales Division, Audio Development Company, 2833 13th Avenue South, Minneapolis, Minn.

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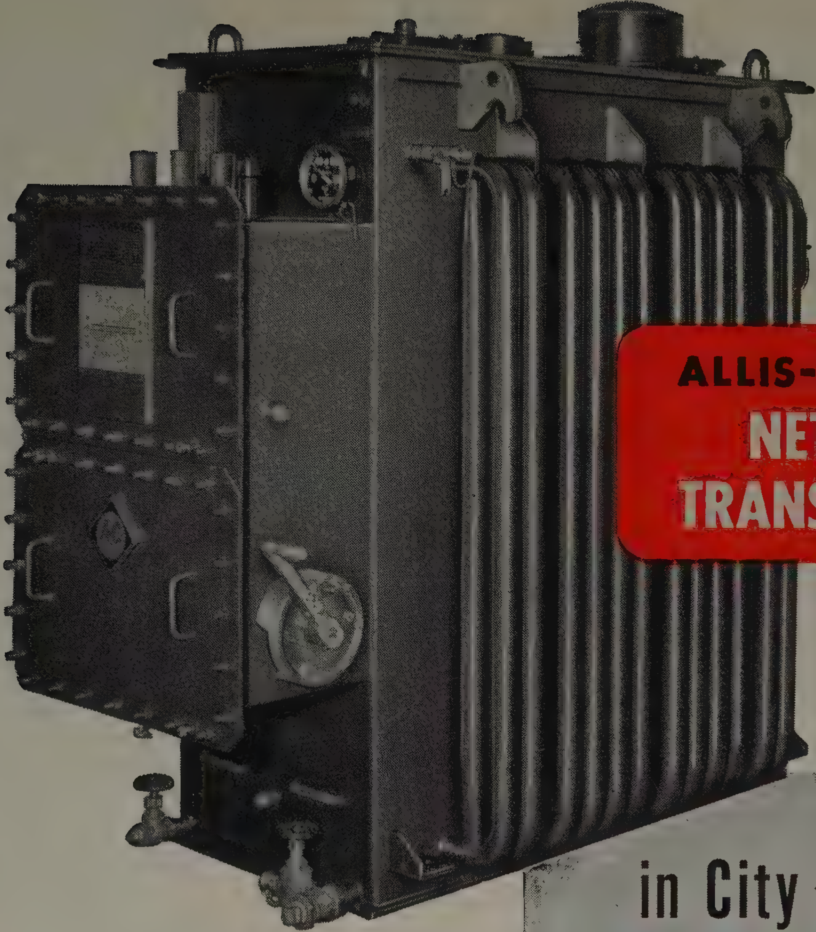


ALLIS-CHALMERS NETWORK TRANSFORMERS

in City after City... PROVED By Performance

On utility systems all over the country Allis-Chalmers network transformers meet the test of reliable and economical service. New A-C network units are ordered repeatedly to take their place alongside the more than 1¼ million kva already installed.

You get unusual flexibility in choice. To simplify your application problems, Allis-Chalmers builds all three basic types: oil-filled, *Chlorextol* liquid-filled, and sealed dry type.

It will pay you to investigate the design and construction details of Allis-Chalmers network transformers before you order your next unit. Consult the A-C district office near you or write Allis-Chalmers, Milwaukee 1, Wisconsin, for more information.

Chlorextol is an Allis-Chalmers trademark.

Compact, low-loss design. Thermal capacities are high for severe load conditions. Sturdy, time-proven core and coil construction withstands repeated short-circuit stresses of network operation.

Safe, dependable tap-changing mechanism. Handle inserted through two-inch opening on cover operates mechanism. Handle cannot be removed unless it is in positive tap position. Cover location of handle entrance eliminates packing gland maintenance.

Threaded valve connections to tank are solder-wiped for extra protection. Valves are located for easy access. Globe-type valves with non-rotating seats close tight, avoid wear on valve seats.

Spiral-wound gaskets have proved their superiority over other types of gaskets for sealing bushings in the tank wall in over 6 years' continual use. Alternate plies of preformed springlike metal and non-metallic fillers provide unusual resilience and actually adjust themselves to changes in operating conditions. Gaskets can be installed without cements or grease. They can be quickly removed if required and may be re-used if necessary.

Shot blast cleaning, three coats of baked-on paint formulated for high water resistance, and compound treatment of base and tubes in base area give superior surface treatment. A-4317

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

(*Continued from page 30A*)

Flat "Pan" Capacitor. A new type of ceramic capacitor which simplifies the design of vhf by-pass circuits, particularly in military electronic equipment, has been announced by the Sprague Electric Company. Called Flat Pan Ceramic Capacitors, these units consist of one to four sections in a shallow metal pan filled with a protective phenolic resin for moisture protection. They are available in voltage ratings ranging from 100 to 500 volts d-c, and in various capacitances depending on the ceramic body. Complete details are given in the Engineering Bulletin Number *611*, available on letterhead request to the Sprague Electric Company, 321 Marshall Street, North Adams, Mass.

Communication Equipment. The General Electric Company has announced the addition of a new 15-watt mobile unit and a new 15-watt base station unit to its line of low-band (25–50-mc) 2-way radio communication equipment. The new 2-way radio unit may be operated, without additional equipment, from either a 6- or a 12-volt power source. The power supply chassis of the new mobile unit is a dual-interrupter-type vibrator which makes possible the use of either a 6- or a 12-volt operation interchangeably. In addition, the car battery can have either positive or negative ground without the problem of determining polarity when installing the mobile unit. Both the mobile and the base station combinations are available for either narrow-band (20-kc channel) or wide-band (40-kc channel) operation.

Battery Charger. A new industrial-type battery charger for emergency generator sets as well as for general industrial usage, has been placed on the market by Automatic Switch Company, Orange, N. J. When used with electric plant starting batteries, its purpose is to keep the starting battery of the emergency set at the properly charged level. Almost all battery charger units will handle either two or three a-c input voltages with one d-c output. For different supply voltages, it is merely necessary to change input connections.

Miniature D-C Solenoid. To fulfill applications requiring the use of d-c solenoids considerably smaller in size and lighter in weight than standard, Cannon Electric has introduced the first two of a new series: numbers *20288* and *20287*. The former has a coil enclosed in a steel shell and the latter, an open coil with a bracket. They measure 3/4 inch in diameter and approximately $1^1/_2$ inches in length. Either may be wound for a wide range of direct voltages. Their weights are 0.122 and 0.141 pound respectively. They are described, illustrated, and dimensioned in Bulletin *PR-S2*, and may be obtained from Cannon Electric Company, 418 West Avenue 33, Los Angeles 31, Calif.

New Universal Noise Generator. A new unit for measurement of noise factor in any receiver has been announced by the

(*Continued on page 40A*)

(*Continued from page 32A*)

Hickok Electrical Instrument Company. It is completely self contained with no additional equipment required, and quickly indicates the amount of noise inherent in receivers to permit correction of this interference. Known as the Model *755*, this unit contains two indicating meters and is divided into a VTVM section and a generator noise section. For complete information write to The Hickok Electrical Instrument Company, 10515 Dupont Avenue, Cleveland 8, Ohio.

Miniature Electric Recorder. A new lightweight, direct-writing recorder for voltage and current records, in both a-c and d-c models, has been announced by the Weston Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, N. J. Weighing only $7^1/_2$ pounds, and with the self-shielded CORMAG (registered trade mark) instrument mechanism, its wide field of usefulness includes: recording ampere-hour demand in power company surveys; checking reports of low voltage, overloads, or unbalanced conditions; monitoring radio detectors when used with electronic amplifiers; recording current and duration in electroplating and metal refining; recording speed, as well as life tests of batteries of all types, lamps, etc. Complete information on ranges, specifications, and prices are available in bulletin form.

Power Rectifiers. A new line of Stavolt d-c power rectifiers has been announced by McColpin-Christie Corporation of Los Angeles, Calif. The company's Stavolt units are closely regulated by a unique magnetic amplifier control of stable and permanent qualities. No tubes, lamps, carbon poles, or varistors are employed. Ten standard 28-volt production models with capacities up to 1,000 amperes in either mobile or stationary types are available. For complete information write for Bulletin *AC-54* to McColpin-Christie Corporation, 3410 West 67th Street, Los Angeles 43, Calif.

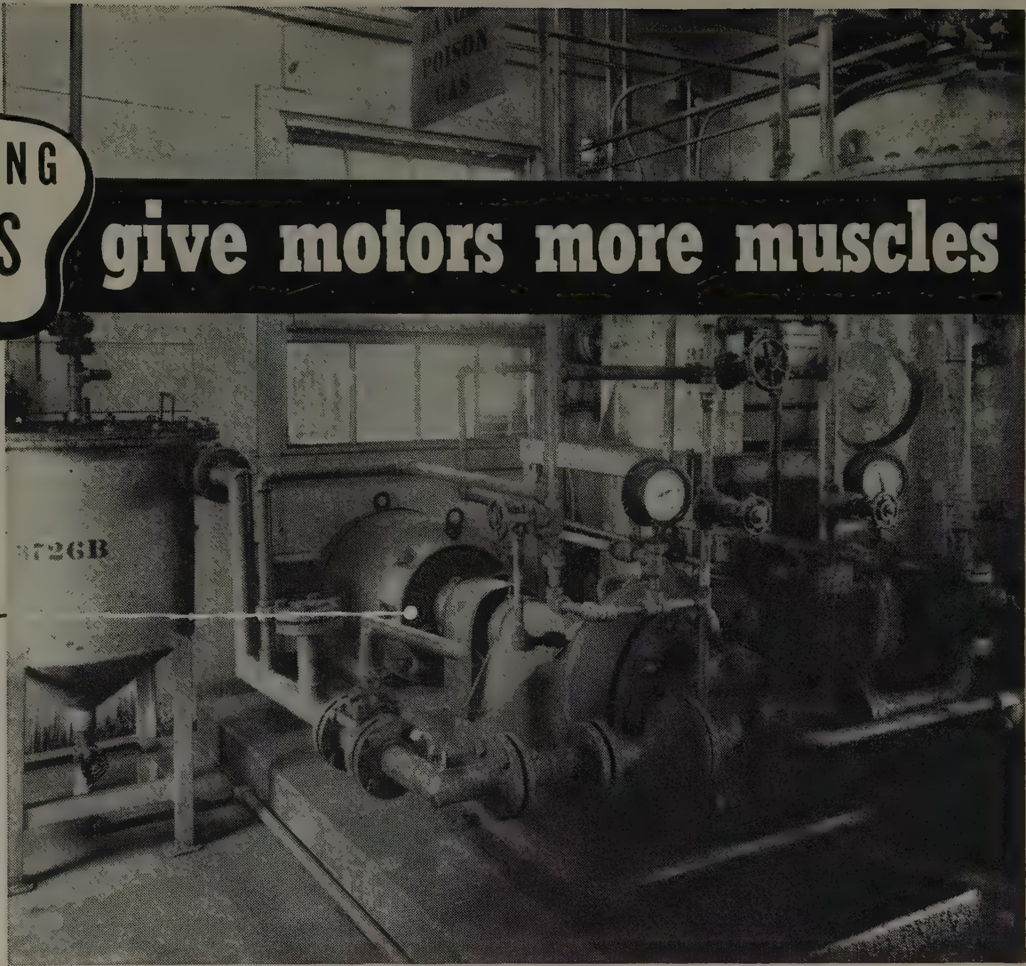
Resistors. Dale Products, Inc., of Columbus, Nebr., has announced that its Dalohm Type *WWL* and *WWA* lightweight, noninductive, wire-wound precision resistors are now being encapsulated for hermetic sealing. The company reports that its research staff has been able to compound a chemically inert material which makes possible these lightweight resistors that surpass the requirements of *MIL-R-93A* and other applicable JAN and MIL specifications. Further information may be obtained by writing to the manufacturer.

Meterless Resistance Instrument. A new test instrument for resistance measurement, compact enough to be held in the user's hand, has been announced by Industrial Development Laboratories, Inc., 17 Pollock Avenue, Jersey City, N. J. Called the Signa-Glow, Model *R-10*, the instrument features a unique null indicator incorporated in the wheatstone bridge circuit with a range from 5 ohms to 50 megohms.

(*Continued on page 44A*)

DOW CORNING SILICONES

give motors more muscles



Uprate 40 hp Compressor Motor by 25%; Eliminate Shut downs; Save $1500

In one step of a complicated production process worked out by Sharples Chemicals Inc. of Wyandotte, Michigan, a conventional 40 hp compressor motor is used to liquify hydrogen sulphide. When other steps in the process were streamlined to increase production, a heavier load was placed on this motor as indicated by an increase of about 17% in its power consumption.

As a result, thermal breakers frequently shut off the motor. The entire process was interrupted; production costs were increased; and an objectionable gas backed into the idle compressor and leaked into the building.

On inquiry, the motor manufacturer suggested that the old motor be uprated by rewinding with silicone (Class H) insulation rather than install a new 50 hp motor costing $2,000. Following this recommendation Sharples engineers had the motor rewound with Class H materials at a cost of only $450 or less than one-fourth the new motor cost.* Reinstalled with higher thermal breakers, that rebuilt motor is still operating after two years of service without causing a single shut-down.

If increased production demands or tough operating conditions are limiting the life and performance of your electrical equipment, put Class H insulation to work for you. Available from all leading rewind shops and on order from new equipment manufacturers, motors insulated with Class H materials made with Dow Corning silicones last 10 times as long or deliver up to 50% more power than conventional motors of the same size.

* Rewound by Howard Electric Company, Detroit, Mich.

You can also reduce to a minimum motor outages due to bearing failure by using Dow Corning 44 Grease

In open and single shielded bearings designed for high temperature operation, Dow Corning 44 has 8 to 10 times the life expectancy of conventional greases. It gives life-time lubrication in permanently sealed bearings.

first in silicones

DOW CORNING CORPORATION

MIDLAND, MICHIGAN

mail this coupon today!

Dow Corning Corporation, Dept. H-19, Midland, Michigan

Please send me

- ☐ More performance data on Class H
- ☐ List of Class H rewind shops
- ☐ List of Class H Motor and ☐ Class H Transformer Manufacturers
- ☐ "Tall Tales and Fabulous Facts" about silicone products

Name________ Title________

Company________

Address________

City________ Zone____ State____

Branch Offices ATLANTA • CHICAGO • CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEW YORK • WASHINGTON, D. C. (SILVER SPRING, MD.)
Canada: Dow Corning Silicones Ltd., Toronto • England: Midland Silicones Ltd., London • France: St. Gobain, Paris

(*Continued from page 40A*)

The instrument accurately determines resistance values within seconds; no recalibration is required. Inquiries regarding the Signa-Glow, Model *R-10,* and other similar bridge instruments for special applications, should be addressed to the manufacturer.

Balanced Modulator for Pulse Applications. The new General Radio Company's Type *1000-P7* balanced modulator has a modulation-frequency response flat from direct current to 20 mc, thus making it suitable not only for short pulses but for any wide-band modulation. The usable carrier-frequency range extends from 60 to 2,300 megacycles, and 100 per cent amplitude modulation can be obtained throughout this carrier range. Double-sideband suppressed-carrier modulation, and pulse modulation with 60-db carrier suppression between pulses are also possible throughout the entire carrier frequency range.

New Imported Midget Megohmeter. A small megohmeter called the Mighty Midget is a new, West German engineering development which has just been imported for the American market by R. A. Koeneman Company, 1408 Delmar Boulevard, St. Louis, Mo. The Mighty Midget is so small it can be slipped into a coat pocket; locked in the glove compartment of a car or tool box. It has a 50-megohm capacity; 500 volts d-c constant voltage with electronic control.

New Colorimeter. The accurate matching of colors is becoming more and more important in industry, particularly in the laboratories of firms engaged in the manufacture of paints, dyes, and color light signals. A new colorimeter shown at the British Industries Fair is a considerable advance on previous instruments of this kind. Based on the designs of R. Donaldson, a member of the staff of Britain's National Physical Laboratory, it uses six matching stimuli where only three had been used before. The advantages are that the spectral energy distribution of the six matching colors can be made to approximate very closely most colored materials and light sources, and the mixture is very nearly independent of the observer's color vision. The manufacturers are Bellingham and Stanley, Ltd., 71 Hornsey Rise, London N. 19, England, and the colorimeters are being distributed by C. A. Brinkmann and Company, 378 Great Neck Road, Great Neck, N. Y.

Mercury Lamp. A 42-per-cent increase in light output of General Electric's 400-watt color-improved reflector mercury lamp, *H400-RC1*, has been announced by the General Electric Company's Lamp Division. The improvement steps up the lamp's light output from 12,300 lumens to 17,500 lumens. This increase in light output has been made possible by utilizing the fluorescent phosphor on the lamp's inner surface as the reflector and by elim-

(*Continued on page 48A*)

Westinghouse gives you the most complete lines of matched instruments

The Westinghouse switchboard instrument lines are the most complete in the industry. This means you get complete coordinated styling or match-up that would otherwise be impossible. In addition, you get better readability under all lighting conditions.

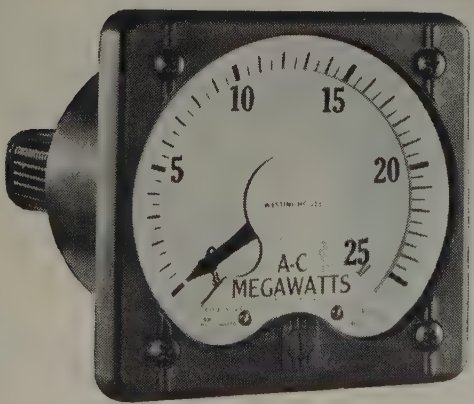
Westinghouse switchboard instruments are available for a-c and d-c current and voltage, single and polyphase watts and vars, frequency, power factor, synchronism, temperature, ground detection and synchrotie position indication.

Every Westinghouse switchboard instrument is built to the exacting performance and dimension specifications of the American Standards Association. Rigid quality-control procedures assure a dependable product. For these reasons, they are standard equipment on all types of switchboards for power stations, on ships, in radio and television stations, and in laboratories and industrial applications.

For all your switchboard instrument requirements, refer to Westinghouse catalog section 43-200. Many ratings can be shipped immediately from stock. Ask your nearest representative or write to Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

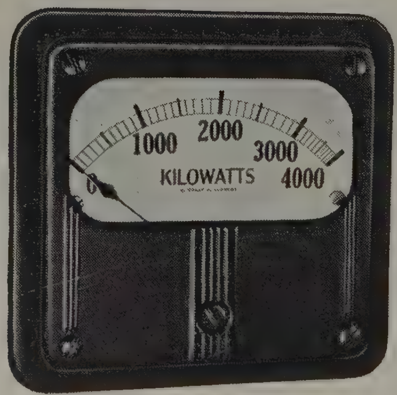
J-40464

Make your choice . . . circular or conventional scale types. Westinghouse gives you both for every switchboard instrument application



TYPE K-24

Westinghouse K-24 full-view instruments are easy to read—even from distances greater than 20 feet or from angles up to 65 degrees. Shadows and glare are reduced to a minimum, even under the most adverse lighting conditions.



TYPE 25

Westinghouse Type 25 switchboard instruments have conventional scales. Like K-24's, they feature non-aging springs, pre-aged permanent magnets, low-friction pivots and a permanently white, indestructible dial.

YOU CAN BE *SURE*...IF IT'S

Westinghouse

(*Continued from page 44A*)

inating the metallic coating. Visible red radiation, emanating from both sides of the phosphor particles, is said to be the chief factor in improving the color quality of light from the new lamp.

Resins. A new and versatile group of epoxy resins and their hardeners have been announced by Bakelite Company, a Division of Union Carbide and Carbon Corporation. The two new epoxies, Bakelite *C-8* resins *BR-18774* and *BR-18795*, combine with four new hardeners especially synthesized for them to form strong, lightweight products with excellent chemical resistance and electrical properties.

Pumping Control. Federal Electric Products Company is now producing a complete new line of both single-phase and 3-phase oil well pumping control. Federal "Noark" oil well pumping control is designed for across-the-line starting of squirrel-cage motors used to drive oil well and other types of pumps.

TRADE LITERATURE

Wire and Cable Book. A 140-page illustrated book containing engineering references and descriptions of insulated wire and cables made for the electrical utility industry has been prepared by the electrical wire and cable department of United States Rubber Company. The new book contains chapters on the company's insulation compounds, jacket compounds, service cables, power and lighting cables and wires, bare and weatherproof wires and cables, portable cords and cables, and insulated aluminum conductors. Complete descriptions, including engineering data, are given on each product. A copy of the book can be obtained, without charge, by writing to the electrical wire and cable department, United States Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.

I-T-E Electronic Components. Catalogue *R-200* is a new 36-page guide to I-T-E electronic components. It fully describes the company's subminiature resistors, precision and power resistors, camera- and receiver-type deflection yokes, focus coils, and i-f and r-f transformers and coils. Charts, tables, and drawings, as well as selection and application information, round out the contents of this useful book. Write to I-T-E Circuit Breaker Company, 19th and Hamilton Streets, Philadelphia 30, Pa., for copies.

Industrial Micarta Plastic. A 50-page catalogue on industrial Micarta plastic is available from the Westinghouse Electric Corporation. Actually a handbook from

(*Continued on page 54A*)

Check the following advantages of U.S. Grizzly® Pre-assembled aerial cables over ordinary open-wiring installations.

1. Less tree trimming is required, and therefore is less objectionable to the community. Can usually be installed in a more direct route.

2. Longer spans and fewer poles due to messenger's great strength.

3. Better appearance because of the elimination of cross-arms and less congestion at the poles.

4. Better service continuity because of high strength supporting messenger.

5. Better voltage regulation because the conductors are bound closer together.

6. Lower installation and maintenance costs.

7. Permits shorter poles.

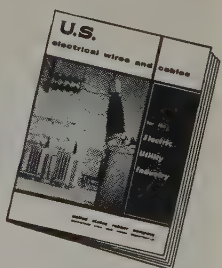
8. Made by United States Rubber Company, specialists in electrical insulation, the only electrical wire and cable producer to grow its own natural rubber, make its own synthetic rubber and manufacture its own plastics.

For more information, write to address below.

U. S. Grizzly pre-assembled aerial cable, 15,000 volts. Type RR —3 conductor, Uskorona® ozone-resistant insulation — shielded — Neoprene jacket.

FREE BOOKLET

Write for your copy of free booklet giving full information about U.S. Electrical Wires and Cables for the Electric Utility Industry.



UNITED STATES RUBBER COMPANY

Electrical Wire and Cable Department • Rockefeller Center, New York 20, N. Y.

(*Continued from page 48A*)

the standpoint of technical information, the new spiral-bound catalogue was prepared for the designer and user of industrial materials. For a copy of this catalogue, *B-5878*, write Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh, Pa.

Instrument Transformers. A 30-page catalogue on instrument transformers has been published by R. E. Uptegraff Manufacturing Company. Designed to present the basic information an engineer requires for specifying Uptegraff instrument transformers, the brochure includes data on current and potential transformers for indoor and outdoor applications. In addition to photographs and descriptive details, the catalogue provides performance data, dimensional drawings, and tables showing cost and weight for various ratings. Copies of this brochure may be obtained from R. E. Uptegraff Manufacturing Company, Scottdale, Pa.

Mechanical Instrument Catalogue. A new catalogue, *M-2A*, just published by the Weston Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, N. J., illustrates and gives complete basic information on their complete line of mechanical industrial instruments. Copies of this catalogue, as well as complete listing of 9-, 10-, and 12-inch circular recorder charts, are available by writing the manufacturer.

Airco Offers Safety Booklet. "Safety" is a new 32-page booklet now being offered by Air Reduction. It is specifically designed for welding and cutting operators handling oxyacetylene and arc welding equipment. Copies of this booklet may be obtained by writing to Air Reduction Sales Company, 60 East 42d Street, New York 17, N. Y.

Laminations Catalogue. Magnetics, Inc., of Butler, Pa., has issued a new magnetic lamination catalogue, describing the company's standard line of laminations, laminated cores, and dies. Catalogue *ML 101*, "Performance Guaranteed Magnetic Laminations," includes many pages of lamination specification sheets, showing both the individual laminations to actual scale, as well as properties of square cross-section core stacks, and weights and counts for different materials. Copies may be obtained by writing Magnetics, Inc., on company letterhead.

Repair Handbook. A 48-page illustrated repair handbook showing, in detail, methods for a wide range of repairs in the factory and home with Smooth-On repair cements is available free of charge from Smooth-On Manufacturing Company, 570 Communipaw Avenue, Jersey City 4, N. J. Text and illustrations present repair methods for leaks in pipes, boilers, radiators, concrete and cinder

(*Continued on page 60A*)

Amerclad lasted 12 years"

Says Chief Electrician, Hudson Plant
Universal Atlas Cement Company

Year after year, at this quarry, the Amerclad is exposed to knife-sharp fragments of flying rock. During the summer, the rock often gets so hot that you can't even touch it. Other times, the cable lies out in the rain and snow—often at sub-zero temperatures.

At the Hudson, N. Y. quarry of Universal Atlas, Chief Electrician Frank Rodmond said, "This Amerclad runs the constant danger of being hit with flying rock fragments through secondary blasting. Yet the down-time cost of this operation is so high that we just can't stand cables that keep failing. We kept that last batch of Amerclad 12 years before we replaced it, yet it was still serviceable when we switched over to new Amerclad."

If you want service like this, specify Amerclad the next time you need cable that can really take it. Amerclad is available in a great many sizes and constructions, with or without shielding. There is a type to power anything from a river dredge or mine locomotive down to a rough and tumble electric hand drill. *Send the coupon,* and get more information.

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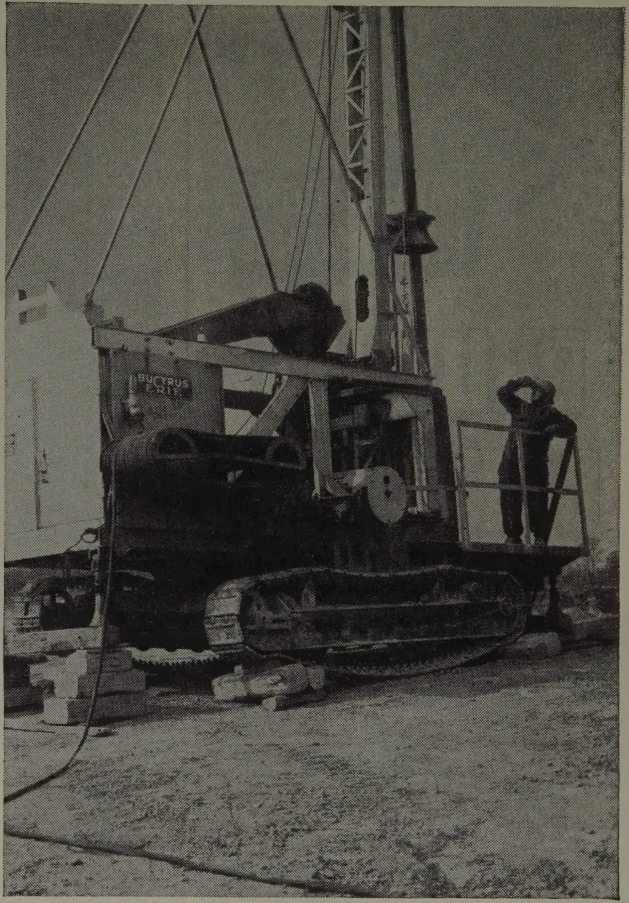

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U·S·S Tiger Brand ELECTRICAL WIRE & CABLE USS

UNITED STATES STEEL

(*Continued from page 54A*)

blocks, and sheet and plate metal. Many other applications are given in this new handbook.

Electrical Controls. Announcement of the publication of a new booklet, "Electrical Controls for the Textile Industry," has been made by the Arrow-Hart and Hegeman Electric Company, Hartford, Conn. The new folder contains detailed information on electrical controls that have been engineered and specifically constructed for textile applications and are not adaptations of present equipment. Copies of the free booklet can be secured by writing the manufacturer.

Tubes. The "A" (Acetaldehyde) to "X" (Xylene) of aluminum heat exchangers is the subject of "Alcoa Aluminum Heat Exchanger Tubes," latest in the Aluminum Company of America technical booklet series. Alcoa's new 24-page booklet presents the complete story on aluminum heat exchanger tubes, emphasizing factors that provide the combination of low cost and corrosion resistance which makes aluminum heat exchanger tubes attractive to industry. Copies are available through Alcoa Sales offices or on request to Aluminum Company of America, 728 Alcoa Building, Pittsburgh 19, Pa.

Electrical Indicating Instruments. A new 48-page catalogue of electric indicating instruments, laboratory portables, and panel meters of finer accuracy has been announced. Illustrated and including specifications of the more popular size meters, as well as 250° arc-angle sealed and ruggedized types presently available, this catalogue is made available by writing to The Hickok Electrical Instrument Company, 10515 Dupont Avenue, Cleveland 8, Ohio.

Trig-Pal Chart. Heller Engineering and Manufacturing Company, of Lynwood, Calif., has released a novel and useful promotional item to their trade. The item is a chart, unique in its practical simplicity, that spells out the equations for any trigonometrical shape. The chart is called Trig-Pal. It is 17 by 22 inches in size for convenient hanging on the wall, is tinned top and bottom for wear protection, and is plastic coated so it may be kept clean. The chart itself shows the equations to learn the unknown factor when other factors are known. It operates for right angle, oblique angle, compound, and spherical trigonometry. The Trig-Pal chart is copyrighted and manufactured by James D. Volts Associates, P. O. Box 621, Culver City, Calif., a public relations firm. Address inquiries to Heller Engineering and Manufacturing Company, 11750 Alameda Street, Lynwood, Calif.

Johns-Manville Folder. "Transite-Pallite" is the title of a 4-page illustrated folder just issued by Johns-Manville. It contains

(*Continued on page 62A*)

(*Continued from page 60A*)

up-to-date information on Transite-Core plates and slip jackets. It also presents their newest asbestos product for the foundry trade; Pallite plates and form driers developed especially for dielectric and electronic furnaces. The folder covers recommendations for use, performance characteristics, and illustrations of the materials in service. Copies of this new folder are available from Johns-Manville, 22 East 40th Street, New York 16, N. Y.

Chart Offered. A handy pocket-size chart of Fahrenheit and centigrade temperature equivalents can be had without obligation from the Moeller Instrument Company of Richmond Hill, New York 18, N. Y., or their representatives located in principal cities. The reverse side of the chart illustrates by means of an animated demonstration, the easy reading qualities of their thermometers made with Moeller glass red reading column. The chart is $8^1/_2$ by $3^1/_2$ inches in size It can easily be carried in the pocket or wallet or may be placed under glass desk tops for easy reference.

Circuit Breakers. Pacific Electric Manufacturing Corporation has just published an 8-page booklet entitled "Type *RHE* Reclosing Oil Circuit Breakers." The type *RHE* circuit breaker was designed to meet the requirements of 3-cycle interruption of the largest fault currents, followed by high-speed reclosing. Confirmation of the interrupter design was obtained from the tests at the Grand Coulee Switchyard and from extensive switching of large shunt capacitors. Complete information including tests and ratings are in this new booklet.

Antennas. A new 24-page booklet describing vhf superturnstile antennas is now available on request from the Engineering Products Division, Radio Corporation of America, Camden 2, N. J. Designated as Catalogue *B.739* this booklet contains illustrations, tables, specifications, mounting data, and vhf antenna accessories.

Miniature Tone Control. A miniature potentiometer with a *DP-DT* slide switch which operates at either extreme of shaft rotation, has been announced by the Electronic Components Division, Stackpole Carbon Company, St. Marys, Pa. This new Stackpole Type *LRSS-150* 0.5-watt control replaces the former *LPSS-3* with space and weight savings plus improved switching action. It carries the same 0.5-watt rating and specifications as other popular Stackpole Series *LR* controls. A Stackpole *SS-150* slide switch mounted on the rear of the control uses separate indenting for each pole, and a special fibre-surfaced laminated Bakelite base for reduced arc tracking and increased safety factor. In operation, the switch short-circuiting bar moves whenever the control shaft is rotated from maximum clockwise, to maximum counterclockwise position, or reverse. Bulletin giving full details is available from the manufacturer.